UNILATERAL HYPERPLASIA OF THE MANDIBULAR CONDYLE

An experimental investigation

PROMOTOR : PROF. C.A. MERKX

UNILATERAL HYPERPLASIA OF THE MANDIBULAR CONDYLE

An experimental investigation

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE GENEESKUNDE AAN DE KATHOLIEKE UNIVERSITEIT TE NIJMEGEN OP GEZAG VAN DE RECTOR MAGNIFICUS PROF. MR. F. J. F. M. DUYNSTEE, VOLGENS BESLUIT VAN HET COLLEGE VAN DECANEN IN HET OPENBAAR TE VERDEDIGEN OP VRIJDAG 22 JUNI 1973 DES NAMIDDAGS OM 4 UUR

door

KONSTANTINOS LEKKAS

GEBOREN TE OUD KORINTHE GRIEKENLAND

1973

Scheerders van Kerchove N.V. Sint-Niklaas, België

Aan mijn ouders
Aan mijn leermeesters

Bij het tot stand komen van dit proefschrift wil ik dank betuigen aan:

1. Drs. W.F.J. Besling afd. Mondheelkunde (Hoofd Prof. C.A. Merkx).
2. Dr. P.J.W. Stoelinga en Dr. R.F. van Hoof (afd. Mondheelkunde, Hoofd Prof. C.A. Merkx).
3. Drs. M.A. van 't Hof, Drs. W.A. Doesburg en Drs. J.A.M. van Druten van de mathematisch statistische afdeling (Hoofd Drs. Ph. van Elteren).
4. Drs. J.H. Peters van de afdeling Pathologische Anatomie (Hoofd Prof. Dr. P.H.M. Schillings).
5. Mej. J.W.M. Renkens en de heer S.J.A.M. Nottet van de tandheelkundige Research laboratoria (Hoofd Dr. P.J. van Mullem).
6. De heren J.W. Reitsma en G.J.M. Poelen van het centraal dierenlaboratorium (Hoofd Dr. M.J. Dobbelaar).
7. De heren A.T.A.J. Reynen, I.L.M. van de Kamp, H.A.W. Bongaarts, T.C. v. Hout en J. Luikens van de afdeling Medische Fotografie.
8. De heer E. de Graaf en zijn medewerkers van de Medische Bibliotheek.
9. De heer L.J.H. Hofman van de tandeelkundige biblotheek.
10. Mej. M-L. Kropmans en Mevr. T.M.C. de Waal-Janssen, die het typewerk verzorgden.
11. De heer H.C.M. Reckers, van de afdeling medische illustratie.
12. De heer T.H. Van Winsen, die voor de vertaling gezorgd heeft.

CONTENTS

INTRODUCTION

— Since it was first described by Adams (1836), unilateral hyperplasia of the mandibular condyle has been a focus of interest in the literature. This interest, however, has been largely confined to the development of surgical techniques to correct the disfiguring facial asymmetry associated with this abnormality. Relatively few investigators have extended their interest to a histological study of the condyles extirpated in these cases.

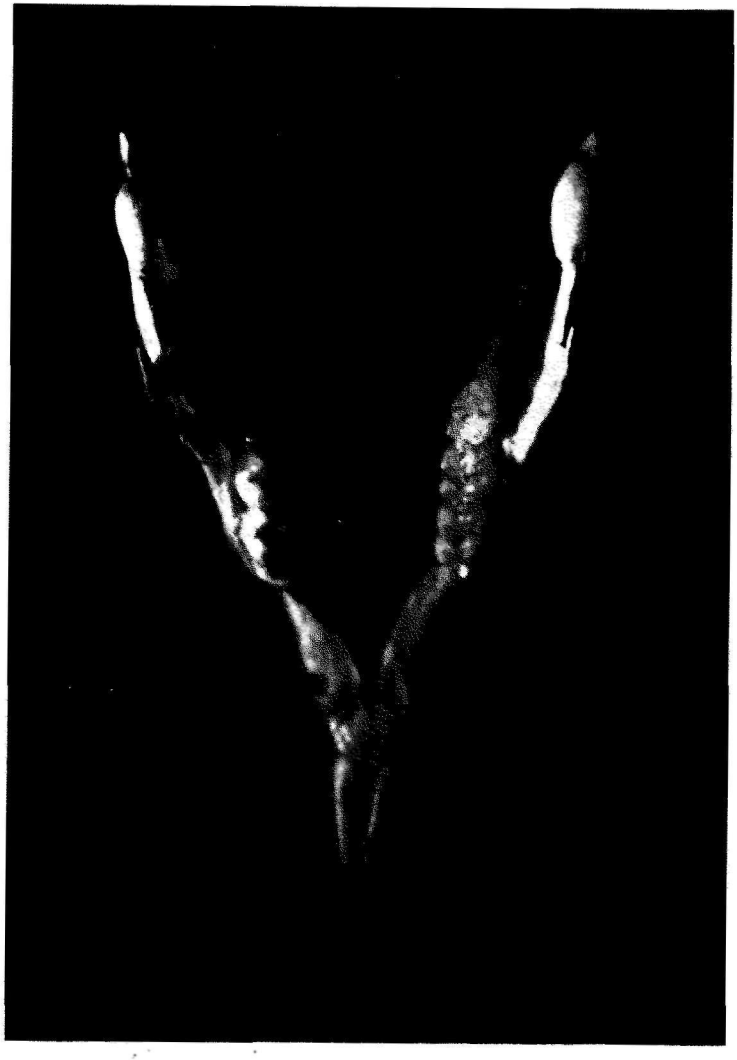
— All existing theories on the actiology of unilateral hyperplasia of the mandibular condyle are based on the — scantiy — personal observations of the various individual authors. One gains the impression that, consequently, unilateral hyperplasia of the mandibular condyle has been too readily linked with various abnormalities which happened to be present in the same patient. To my knowledge, none of the relevant publications reports an attempt to test aetiological theories in animal experiments.

— A study of the literature and of the data on ten patients who were treated for this abnormality in the Department of Oral Surgery (head : Prof. C.A. Merkx), St. Radboud Ziekenhuis, Catholic University, Nijmegen, suggested to me that a traumatic lesion, particularly if sustained at an early age, can be an important factor in stimulation of the growth of the mandibular condyle.

— On the basis of this impression, efforts were made to stimulate endochondral growth of the mandibular condyle by means of a standardized traumatic lesion in animal experiments.

— The traumatic lesion was produced folowing an operative approach to the temporomandibular articulation itself or its immediate vicinity.

— The influence of a number of additional factors, which might be of importance in the aetiology of unilateral hyperplasia of the mandibular condyle, was likewise studied.



CHAPTER I

REVIEW OF THE LITERATURE

History

— As far as can be established, Adams was the first, in 1836, to describe the clinical features of unilateral hyperplasia of the mandibular condyle. His patient was a woman suffering from generalized rheumatoid arthritis, which Adams regarded as the cause of the hyperplasia. Humphrey (1856) was probably the first to perform extirpation of an enlarged mandibular condyle.

— Several patients with a similar abnormality have since been described, e.g. by Eves (1883), Von Eiselsberg (1906), Gruka & Meisels (1926), Leproust (1927), and Perthès (1932). With Rushton's publication (1946) the number of cases described had already increased to 32.

— Commissionat (1952) presented in his Thesis an extensive study of the literature on unilateral condylar hyperplasia until then. The total number of such patients so far described in the literature is approximately 100 or more.

Incidence of the abnormality

— The question whether this hyperplasia occurs, frequently is controversial. Thoma (1945), for example, regards it as « a very rare disease », and his opinion is shared by Dufourmentel (1929), MacNichol & Roger (1946), and Schulz *et al.* (1960). Wang-Norderud and Lossius (1948), however, gained the impression that : « It cannot be excluded that minor hyperplasias occur more frequently than the extreme cases mentioned ». Egyedi (1964), finally, considers it difficult to determine the frequency; in his view many cases of « laterognathism » and « prognathism » are also based on condylar hyperplasia, but the abnormalities are not recognized as such and therefore not classified under this heading.

Nomenclature

— Since Rushton's publication (1946), the designation « unilateral hyperplasia of the mandibular condyle » has been accepted by most authors.

By this term he means benign unilateral enlargement of the mandibular condyle. This designation is used by such authors as MacNichol & Roger (1946), Gottlieb (1951), Van Zile (1954), Broadway (1958), Berry (1958) and Öberg *et al.* (1962). Perriman *et al.* (1971), Graziani (1972). Others (e.g. Reichenbach & Seidler 1948; Commissionat 1952; Flohr 1952; Zanka & Muryhy 1954; Layani *et al.* 1954) still use the term « hypertrophy ». Some authors (Cernéa *et al.* 1956; Worman *et al.* (1946) prefer the term « osteoma ». Melarkey *et al.* (1966) base their use of the term « osteochondroma » on the fact that the hyperplastic condyle contains osseous as well as cartilaginous components.

— In conformity with the majority of authors in this field, the term « hyperplasia » or « unilateral hyperplasia of the mandibular condyle » is used in this study.

Nature of the abnormality

— The majority of case reports in the literature mention explicitly that there is no familial occurrence of this hyperplasia. In some cases it is in fact emphasized that no prognathism was demonstrated in relatives.

— Routine hematological test and serum calsium, phosphorus and alcaline phosphatase in al cases have been reported to be wthin normal limits.

— Leproust (1927) observed a positive Wassermann reaction in his (two) patients, but this finding is no longer mentioned in subsequent publications.

— Van Zile (1954) made a hormonal study of his patient, without specifying the exact nature of this study, and reports that no abnormalities were found.

— There is no male or female predominance. Nor is there evidence of predilection for the right or the left condyle (Commissionat 1952).

— Wang-Norderud & Lossius (1948) observed bilateral hyperplasia in one of their patients. However, it is difficult to diagnose bilateral condylar hyperplasia.

— Limitation of mandibular movement has not been noticable featur in any of the cases reported. Most of the patients attended for treatment purely for cosmetic reasons. An obtrusive facial asymmetry entailed by unilateral hyperplasia.

— It has often been reported that the extirpated condylar process is « evidently enlarged » or that it seems to be « half as large again » or « twice as large » as the normal, unextirpated, condylar process.

— In the description of the macroscopic features of unilateral hyperplasia of the mandibular condyle, the following terms will be used, derived from the official terminology of the Nomina Anatomica (1970) : head of the mandible or condyle (caput mandibulae), denoting the articulating part of the mandible. This is identical with the upper part of the condylar process. The neck of the mandible (collum mandibulae) is the narrow subcondylar portion of the mandible. The condylar process (processus condylaris) is the extreme dorsocranial part of the mandible (Lindbloom 1960).

— The most characteristic feature which emerges from a description of the macroscopy of unilateral hyperplasia of the mandibular condyle is that, although enlargement is always involved, its nature is rather variable.

— In some cases the condylar process as a whole is proportionately enlarged. In other cases the condyle has remained virtually normal, whereas the remainder of the condylar process is exceedingly long (Cernéa 1948; Van Zile 1954). In many cases, however, it is the condyle that is enlarged while the remainder of the condylar process is hardly affected (Berry 1958; Schulz *et al.* 1960; Öberg *et al.* 1962; Walker 1967; Kessel 1970). Moreover, the hyperplastic condyle itself is not always proportionately enlarged. The enlargement in sagittal and often in transversal direction can be the most pronounced.

— Combinations of the abovementioned possibilities can also be encountered.

— To recapitulate : marked enlargement of only one of the dimensions of the condylar process, with hardly any hyperplasia of the remainder, seems to be sufficient in the literature to warrant the use of the term « condylar hyperplasia ».

— Macroscopically, the articular surface is often flattened, though as a rule it is smooth. The cartilagenous lining is frequently thin, and in some cases entirely absent. In some cases the surface of the cartilage is irregular and nodular (Ivy 1927; Berry 1958). Other authors mention relatively large exostoses at the periphery of the condyle (Gruka & Meisels 1926; Gottlieb 1951; Schulz et al. 1960; Melarkey 1966). Small exostoses have likewise been observed on the articular surface proper.

— In the majority of cases the entire condylar process was removed, and sections were cut throughout the specimen. The histological description is often rather brief, and sometimes confined to the statement that neither inflammatory nor neoplastic process was found.

— With regard to cartilage and bone it can be stated in general that the histological features of the osseous part of the condyle are normal. The histological features of the cartilage, however, are nearly always abnormal. The cartilage varies from an evenly hyperplastic type to one which shows unmistakable degenerative changes.

Bone

— The following findings are of importance with regard to the bone. Gruka & Meisels (1926) mention a normal ratio between cells and intercellular substance. The bone marrow chiefly contains poorly cellularized fatty tissue. Vascular and highly cellular bone marrow was found in the patient described by Flohr (1952); active endochondral growth of bone was quite evident. Zanka & Murphy (1954) found irregular thickening of bone trabeculae. Rushton (1946) and Öberg *et al.* (1962) found remnants of partly calcified cartilage in the spongy bone. In the patients described by the last mentioned authors, the thin, compact layer beneath the cartilage, which should be continuous, in the age group of the patients described was discontinuous.

Cartilage

— The observation reported by Flohr (1952) is interesting with regard to the microscopic features of the cartilage lining of the mandibular condyle. The total thickness of the cartilage had conspicuously increased. The articular surface was smooth. There was proportional thickening of all layers of cartilage except the fibrous layer, which had retained its normal thickness. The ratio between cells and intercellular substance had remained within physiological limits.

— Rushton (1946), Wang-Norderud & Lossius (1948) and Gruka & Meisels (1926) also mentioned this increase in the thickness of the cartilage in its totality. In their view the structure was not quite physiological. Most irregularities were found at the level of the hypertrophic cells.

— Schulz *et al.* (1960) also found that the cells in this layer were not regularly distributed, but accumulated in larger or smaller groups, separated by thick septa of intercellular substance.
— Brown *et* al. (1946) found areas of still-active cartilage alternating with areas showing complete absence of cartilage. Melarkey *et al.* (1966) found some small exostoses, covered by cartilage of variable thickness, on the articular surface. In a similar patient described by Van Zile (1954), the exostosis showed no cover of cartilage.

The development of the abnormality

— Commissionat (1952) distinguished two stages in the course of unilateral condylar hyperplasia. The first was characterized by accelerated proliferation of cartilage, associated with accelerated endochondral ossification, the proliferation being predominant. The second stage was characterized by stabilization. The proliferation of cartilage gradually slowing down, even to below the normal rate.
— In this way Commissionat (1952) attempted to give some explanation of the pathological variations described by various authors. In view of this schematic suggestion, it is understandable that authors such as Melarkey *et al.* (1966) classified the abnormality as chondroma : they probably extirpated the condyle during the first stage. It is also understandable that the term osteoma has been used by others such as Cernéa *et al.* (1956), who performed the operation at a much later stage of development.

Period of development

— The period of time in which the hyperplasia develops cannot be readily estimated. It is generally assumed that the process is arrested until after about 4 years; in extreme cases the condyle may continue to enlarge for longer than 10 years (Öberg *et al.* 1962). The process is self-limiting; once stabilization occurs, no further clinical changes are observed (Walker 1967; Freitag 1970, and others).

Correlation with age

— Nearly all authors point out that unilateral condylar hyperplasia chiefly occurs in individuals aged 15-30. In this respect it should be borne in mind that, when asymmetry is noticed, the process has probably existed for some time.

— Cernéa (1948) pointed out that a correlation must exist between unilateral hyperplasia of the mandibular condyle and the growth spurt, i.e. the accelerated increase in height associated with puberty. MacNichol & Roger (1946) maintained that the asymmetry is clinically most manifest during puberty. Commissionat (1952) concluded that the condylar hyperplasia is an abnormality of the young individual, occurring when the cartilage is still active.

Cause

— Several different suggestions have been made about the causes of unilateral hyperplasia of the mandibular condyle. Von Eiselsberg (1906) believed that arthrosis deformans was the cause, and Reichenbach & Seidler (1948) agreed with him. They base this opinion on the degenerative phenomena found in particular on the articular surface of the condyle.
— In an era when syphilis was regarded as the cause of a whole range of congenital or acquired disorders, Leproust (1927) believed that a correlation with this disease existed. He found a positive Wassermann reaction in his (two) patients with unilateral hyperplasia.
— Several authors have mentioned chronic otitis media in childhood as a possible cause.
— Rushton (1946) suspected that factors which play a role in hyperplasia of the long bones, are involved also in the causation of hyperplasia of the mandibular condyle.
— Egyedi (1964) had the same suspicion, and in addition pointed out that circulatory disorders near the growth zone of the condyle may stimulate the development of hyperplasia. His view was based on a report by Trueta, who observed increased longitudinal growth of the long bones after circulatory disorders in the vicinity of the growth plate in question. Goidanich & Campanacci (1962) described a similar effect from vascular hamartomas in this area. Goof (1960) also mentioned that excessive longitudinal growth can occur in the presence of a local chronic inflammatory process.
— Servelle (1948) demonstrated on the basis of clinical and experimental findings that obstruction of the efferent venous flow can lead to hyperplasia of the limb involved. His findings were later confirmed to some extent by Colt & Iger (1963).
Brookes (1957), demonstrated delayed growth of the femur after severing the nutrient artery and vein at the nutrient foramen. He held that this

occlusion caused simultaneous and prolonged diminution of the arterial blood supply and obstruction of the efferent venous flow of the bone in question.

— The most commonly mentioned cause of excessive longitudinal growth of the long bones, however, is a traumatic lesion.

— Bisgard (1936) demonstrated, in 25 young patients, that hyperplasia of the long bones of a limb had always been preceded by a fracture; and he confirmed this observation in experiments on young goats. He observed that the maximum increase in length occurred during the initial post-traumatic period, whereupon the rate of growth gradually diminished. He also found that the growth plate of the fractured leg calcified earlier than that of the intact limb. In his opinion the hyperplasia must be ascribed to accelerated osteogenesis, i.e. increased activity of the process which normally also governs growth.

— Blomquist & Hogeman (1963) also believed that a traumatic lesion should be considered as the most obvious cause in the case of unilateral condylar hyperplasia.

— Gottlieb (1951) found a history of a fracture in some of his patients. The majority of authors who accept a possible traumatic cause, however, did not establish a history of a fracture. To much reliane cannot be placed in these reports because it is a well known clinial fact that fractures of the condylar process in young patients can heal within a relatively short time without leaving a radiologically visible scar.

Experimental stimulation of condylar growth

— So far, few experimental studies have been devoted to the aetiology and nature of unilateral condylar hyperplasia. The experiments reported by Breitner (1940), Hoffer (1958) and Baume & Derischweiler (1961) resulted in only very slight bone remodeling of the condyle after prolonged ventral traction on the mandible.

— Cimasoni & Becks (1963) extracted the molars from the right maxilla in 40-day-old rats. After 60 days they concluded that there were no histological differences betwen the two condyles. In a similar experiment Lemoine *et al.* (1968) could only demonstrate a slight enlargement of the zone of hypertrophic cells on the side of the extractions.

— After prolonged hyperpropulsion of the mandible in 4-week-old rats, Charlier *et al.* (1969), Charlier (1967) observed only a slight increase of cell divisions in the zone of chondroblasts. Jointly with Petrovic & Link (1969), the same author effected reduction of the thickness of this layer

in rats in whom the condyle was regularly pressed into the fossa by means of a head-chin cap.

— Gupta *et al.* (1971) investigated the influence of abrupt excessive changes in occlusion on the mandibular condyle in rabbits. The initial effect was resorption of cartilage and osteoclastic activity, but the ultimate result was adaptation of the temporomandibular joint and formation of new cartilage and bone.

— In none of the abovementioned experiments was the concept of condylar hyperplasia even mentioned. The only author to refer to it was Sprinz (1954): he observed and mentioned hyperplasia of the mandibular condyle in the course of an attempt to compare the regenerative capacity of the meniscus of the temporomandibular joint with that after extirpation of a meniscus of the knee-joint. His references to the literature indicate that extirpation of a meniscus of the knee-joint is followed by total or partial regeneration. But his experiment showed that a similar operation on the temporomandibular joint is followed by degeneration of the disc. He did observe hyperplasia of the condyle involved. Dubecq (1937), however, had made no mention of condylar hyperplasia in a similar experimental study. He did only report small irregularities on the articular surface of the condyle and found that the damaged articular meniscus had degenerated. Rönning and Koski (1969) also were not able to demonstrate any difference in the side between condyles transplanted with and without menisci.

CONCLUSIONS FROM THE LITERATURE AND PROBLEM STATEMENT

Conclusions from the literature

A number of conclusions can be estableshed from the literature regarding stimulations which leed to excessive endochrondral growth in general and to excessive growth of the condyle in particular.

1. With regard to the growth of the long bones, it can be stated that it is relatively easy to determine the extreme age limit of growth. The calcification of the growth plate delineates the end of physiological growth. After this time, no further endochondral growth is possible, even as a result of stimulation.
2. On the other hand, the time at which physiological endochondral growth of the condyle of the mandible ends cannot be readily determined and is controversial. Some investigators in fact maintain that the condyle retains its ability to grow throughout life. And it is true that endochondral growth of the condyle can be resumed in response to the growth hormone.

   Hyperplasia of the condyle however, or at least its initial phase, is an abnormality which occurs early in life. The number of cases described diminishes with advancing age. Most case reports concern patients under 20; some refer to patients aged 20-30; but the literature mentions virtually no cases in patients older than 40.
3. The majority of authors accept a « traumatic » cause of the hyperplasia, both of the long bones and of the mandibular condyle.

   Experiments on long bones have shown that a traumatic lesion is most effective in producing unmistakable hyperplasia. In experiments on the long bones, « traumatic lesion » always means a fracture of the bone involved.

   The literature rarely mentions a fracture as the cause of hyperplasia of the mandibular condyle. In this respect, however, the difficulty of diagnosis and the rapid healing of such fractures in young individuals must be taken into account. A fracture as « traumatic lesion » can neither be demonstrated nor eliminated, unless a case fulfils currently valid criteria of history and, possibly, functional or radiological changes.

4. Numerous authors have attempted to explain hyperplasia following a single traumatic injury by postulating a vascular disorder as a result of the injury. In this respect, three different views can be encountered. Some authors postulate a disturbance in the efferent venous flow from the bone in question, some suggest that the arterial blood supply is disturbed, while others believe that a combination of these two is the cause.
5. When growth in the long bones is stimulated, the normal growth pattern shows the following changes as compared with that in the limb not stimulated :
   a. acceleration of the growth process during a certain period;
   b. a virtually constant rate of growth during some time;
   c. a reduced rate of growth;
   d. earlier ossification of the growth plate;
   e. the ultimate gain or loss in length is determined by summation of factors a, b, c and d. In order to achieve a certain optimal enlargement in comparison with the nonstimulated limb, one is probably dependent on the correct choise of the time at which the traumatic injury is produced.
6. The articular disc probably plays an important role in the growth of the mandibular condyle.
7. A traumatic injury can cause haemarthrosis of the temporomandibular joint.

Problem statement

— Hyperplasia of the mandibular condyle is the subject of this study. The traumatic theory adhered to by many authors, and personal observations on patients treated in the Department of Oral Surgery, St. Radboud Ziekenhuis, Nijmegen, prompted an experimental study of the effects of a traumatic lesion of the temporomandibular joint as a possible cause of stimulation of endochondral growth of the mandibular condyle.

Experimental design

a. Of different possibilities for the causation of hyperplasia of the condyle mentioned in the literature, the following were tested :
   1) interference with efferent venous flow;
   2) interference with arterial blood supply;

3) interference with both;
4) extirpation of the articular disc;
5) production of haemarthrosis in the caudal compartment of the joint.

b. The method found most effective on the basis of the results obtained, was further elaborated.

CHAPTER III

MATERIAL AND METHODS

General remarks

— The rat is very suitable animal for experiments. Particularly in experiments concerning growth, this test animal has several advantages.

a) Rats have already been used in numerous experiments in widely diferent fields, and many anatomical and physiological data on these animals are thus available.
b) Rats rapidly grow to adulthood, within a few months. The effects of experiments can therefore be fully studied within a reasonable period of time.
c) Rats are resistant to diseases.
d) Albino Wistar rats have been adequately standardized in the animal laboratory of the Catholic University, Nijmegen. Data suitable for statistical analysis are therefore available.
e) The animals are inexpensive and sufficiently small in size to be bred in large numbers.

— The animals required for these experiments were obtained from the TNO Test Animal Breeding Centre in Zeist (Netherlands). With a number of these animals, breeding was continued in the animal laboratory of the Catholic University, Nijmegen (head : Dr Vet. M.J. Dobbelaar). They were divided at random into test groups and control groups.

Animal accommodation and conditions

— The animals were transferred to the laboratory a few days before the experiment, and had become accustomed to the new environment when the experiment was started. They were kept at a constant room temperature of 24°C throughout the experiment.

— The rats were accommodated in metal wire cages, each of which as a rule contained 5 animals. Before the experiment was started, the animals were marked by amputation of a finger or toe (Reitsma 1963).

— The rats were fed the normal rat feed of the experimental laboratory Hope Farms R.M.H.), and given water ad libitum. During the first four postoperative days, however, they were transferred tot plastic cages with

a sawdust-strewn floor; during this period they received a soft diet produced by diluting the abovementioned feed with water until a pulpy mass was obtained.
— The control animals were kept under identical conditions.
— After the operation daily records were kept on body weight, and a brief clinical description was given of each animal. This data was used to gain a general impression of the duration and manner of recovery.

Age and sex of test animals

— To ensure optimal uniformity in the experiments, only male animals were used. The traumatic lesion was produced on the 56th day after birth; according to Hughes & Tanner (1970), the longitudinal growth spurt in male rats ends at his age.

Operative technique

Anaesthesia

— The anaesthesia required was produced by a single intraperitoneal injection of thiopental sodium (Pentothal), the usual dosage being 35 mg/kg body weight. The desired depth of anaesthesia was attained about 10 minutes after injection. Consciousness was regained 2 hours later. The anaesthesia was maintained by infiltrating the field of operation with 2 % Xylocaine solution; this infiltration also reduced bleading during the operation.

Instruments

— The following instruments were used for the operation.
1. A no. 11 blade.
2. One straight and one curved pair of small pointed surgical scissors.
3. A pair of delicate surgical tweezers and a pair of anatomical ophthalmological tweezers.
4. Normal tweezers.
5. A sharp tridentate retractor.
6. Two minute single-prong retractors.
7. Two retractors fashioned from safety-pins in the manner of Bouwman's eyelid retractor.
8. An ASH 49.

9. An excavator.
10. Swabs made of blotting-paper (used in ophthalmology).
11. An ophthalmological needle-holder.
12. Atraumatic catgut 5 x 0, sterile.
13. Atraumatic silk 5 x 0, sterile.
14. Surgical towels for small animals.
15. A special small operating-table.

When necessary, use was made of an electrical, drill angled hand-piece, and Hayatt burs.

Sterilization

— The metal instruments were sterilized by 15 minutes' boiling, the surgical towels and swabs were submitted to dry sterilization.

Operation

— For the sake of uniformity, the operations were performed on the left temporomandibular joint. Use was made of a small operating-table especially designed for rats, with four fixation clamps for the limbs.

Procedure :

— The hair on the operation field is shorn with clippers, the skin is cleansed with alcohol, and the rat's eyes are protected from desiccation by means of an indifferent eye ointment. The animal is then covered with a surgical towel, with an opening through which only the head is exposed.
— A skin incision is made parallel with and slightly below the line between the canthus and the external auditory meatus, over a distance of about 1.5 cm, working in an anteroposterior direction.
— The skn is undermined; the facial nerve is located and left intact, while the extra-orbital lacrimal gland is dissected out and removed. The masseter muscle is then sharply severed over a distance of about 0.75 cm, immediately below and parallel to the docsal end of the zygomatic arch, and parallel to the second branch of the facial nerve. The ascending ramus of the mandible is thus located at the level of the neck of the mandible, about 2.5 mm caudal to the cartilage surface of the condyle.
In this way the temporomandibular joint itself can be located. During the operation, the external carotid, maxillary and superficial temporal arteries are identified and spared. Damage to these vessels would cause severe haemorrhage which would greatly impede the further course of the operation.

— The bifurcation of the external carotid artery into the two above-mentioned terminal vessels is found at the level of the neck of the mandible, about 1 mm dorsal to the ascending ramus. Some slight bleeding from facial vessels is readily controlled by compression with wet swabs.
— A detailed description of the various types of operation employed in order to cause a traumatic injury of the left temporomandibular joint in these test animals, will be given in subsequent chapters.
— The operation is completed by closing the wound in layers, suturing the masseter muscle with atraumatic catgut and the skin with atraumatic silk.

Postoperative course

— All the test animals as well as the controls (which were merely anaesthetized) showed a weight loss of about 10 % of the preoperative weight on the day after the operation. The control group, however, regained normal body weight two days earlier than the test group. Subsequently the two groups showed virtually the same weight gain, but the weight of the test animals continued to be lower than that of controls until the end of the experiment.
— The test group showed moderate swelling of the jaw, which disappeared within 4 days. Pain probably dictated unilateral mastication during the initial postoperative period. This was clinically manifested in the fact that the originally horizontal plane of abrasion of the incisors had become oblique. This phenomenon was most evident on the 4th and 5th postoperative days, and disappeared on the 8th day.

End of the experiment

— On the 16th postoperative day all animals were sacrificed by means of increasingly deep ether anaesthesia. The mandibles were dissected out, prepared, and macroscopically examined, the findings being recorded immediately.
— After fixation in an ample amount of a neutral 4 % formalin solution, all mandibles were again macroscopically examined.

Photographs

— A few days later, standardized photographs of the mandibles were made from a cranial as well as from a lateral angle. For the cranial

exposure the sagittal axis of the condyle was oriented as horizontally as possible.
After division of the mandible at the symphysis, lateral photographs of the two halves were taken.

Radiographs

— The so-called « séinograph » was used to obtain comparable radiographs of the two halves of the mandible. For this purpose, the two halves were placed with the lateral surfaces flat on the film, the tube being kept vertical at a constant distance of 20 cm over the film.

— The séinograph is a roentgen apparatus which emanates a monochromatic X-ray beam, making it possible to obtain highdefinition radiographs of low-contrast objects.

Measurements

— Measurements were made either directly on the mandible or indirectly on the standardised photographs or radiographs of the mandible.

— During the initial phase of the investigation, when the objective was to obtain general information, the necessary measurements were made with ordinary callipers. During the second part of the investigation, we measured with the aid of the so called Optocom.

— The Optocom is a microscope fitted over a two-dimensionally moving stage. The factor of magnification of the microscope is 10. The depth of field without adaptation is 5 mm. The microscope is also equipped with cross-hairs.

— The two-dimensionally moving stage is used to bring a given point into the focus of the cross-hair reticle, whereupon the coordinates of this point are electronically recorded by pushing a button.

— All measurements in the first series of experiments were made in triplicate; those in the second series were made in duplicate.
Dimensions selected for measurement were (Fig. III1) :

a. The maximal length of the condyle in a sagittal direction.
b. Its maximal tranversal diameter.
c. The maximal height of the ascending ramus.

— The data was statistically analysed by the Department of Medical Statistics.

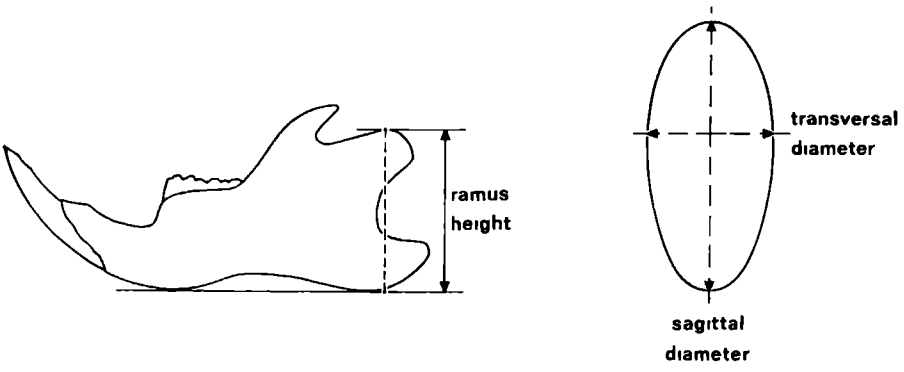


Fig III 1 See the text

Histology

— The condyles were decalcified in an EDTA solution and then embedded in paraffin. Sagittal serial sections of 7-10 μ thickness were cut. Also a few frontal sections were cut to gain a more exact impression of the total picture. The sections were submitted to

a) haematoxylin-eosin staining;

b) Van Gieson staining.

CHAPTER IV

THE TEMPOROMANDIBULAR JOINT OF THE RAT

— This chapter presents some data from the literature on the anatomy, histology and growth of the temporomandibular joint of the rat. Descriptions will be confined to what is relevant to a good understandng of the operations performed, their effects, and basis for comparison with the hyperplastic condyles.

ANATOMY

Osteology

— The temporomandibular joint in young and adult rats can be divided into two parts : the articular fossa and the mandibular condyle.

The articular fossa

— The articular fossa in rodents is a groove in the squamous bone. The longitudinal axis of this groove virtually lies in the vertical plane (Öberg 1964; Collins *et al.* 1946). but shows some slight distocranial inclination. The squamous bone constitutes most of the fossa, i.e. its medial and its cranial wall (the depth of the articular fossa); the zygomatic bone constitutes the lateral wall. The fossa is divided into a ventral and a dorsal part by a small eminence, which is a continuation of the zygomatic process of the squamous bone. The mandibular condyle articulates with the ventral part during gnawing, and with the dorsal part during mastication.
— The neonatal fossa is exceedingly shallow, its depth increasing with age, up to 14-15 weeks (Collins *et al.* 1946), after which it remains virtually unchanged. As a result, the condyle reaches relatively deeper in the fossa in older animals, and therefore intra-articular operations are more difficult in older animals.

The mandibular condyle

— The mandibular part of the temporomandibular joint consists of the

condyle and the neck of the mandible. The condylus in rodents is roughly pear-shaped, with the apex in ventral direction. The longitudinal axis is oriented in the sagittal plane, and is at least twice as long as the transverse axis. The length of the fossa is likewise twice that of the condyle.
— The narrowest subcondylar portion which is the transition between the condylus and the remainder of the condylar process, is known as the neck. It is the site of insertion of the articular capsule.

Myology

— The temporomandibular joint is enclosed by the masseter muscle on the lateral and the pterygoid muscles on the medial side. The temporal muscle can cover the most anterior part of the condyle when this articulates with the ventral part of the articular fossa.
— Information on the masticatory musculature of the rat was obtained from Greene (1955) and Von Schumacher & Rehmer (1962).

Masseter muscle

— This is the strongest masticatory muscle of the rodent. Its origin is mostly on the zygomatic arch, but in addition it has a ventral (maxillo-mandibular) part which has its origin on the infra-orbital plane beneath the zygomatic arch. Its fasciculi take a markedly oblique dorsocaudal course, and insert on the lateral aspect of the mandible and its angle. Some fasciculi, however, continue around the mandibular edge and insert on the medial aspect of the mandible (reflecting part of the muscle). The muscle has two components : a vertical and a protrusive component.

Medial pterygoid muscle

— This muscle has its origin on the lateral aspect of the medial pterygoid process of the skull. Its fasciculi take a caudolateral course and have their insertion on the medial aspect of the mandible and its angle, on which the reflecting part of the masseter muscle also inserts. The function of this muscle is chiefly to close the jaws. In addition it has a protrusive component.

Lateral pterygoid muscle

— This muscle has its origin on the lateral pterygoid process of the base of the skull. Its fasciculi take a virtually horizontal lateral course and

insert on the medial aspect of the condylar process, the medial part of the capsule, and the medial edge of the articular disc. The action of this muscle moves the mandible in anterior and in medial direction.

Temporal muscle

— The origin of this muscle is on the temporal bone and on the parietal bone. Its fasciculi converge and insert on the mandibular muscular process. This muscle is to be counted among the levator muscles, and in addition has a retrusive action.

Articular capsule

— Cunat *et al.* (1956) were unable to identify a continuous capsule enveloping the temporomandibular joint in the rat. The ventral and dorsal parts of the capsule were identifiable as such, but its medial and lateral parts were not distinguishable.
— They ascribed this insufficient development of the medial and lateral parts of the capsule to the presence of the masseter muscle on the lateral and of the external pterygoid muscle on the medial side of the temporomandibular joint. At these sites the perimysium of these muscles plays the role of a capsule. By the term articular capsule we shall henceforth refer to the capsule as described above.

Articular disc

— This is a relatively thick disc of fibrous tissue, which is thinner at the centre than at the periphery. Its upper surface is slightly convex and adapted to the fossa, whereas its under surface is concave and articulates with the mandibular condyle.
— The disc completely divides the joint into an upper and a lower compartment, the former being substantially larger than the latter and more elastic.
— The lateral and medial sides of the disc insert into the articular capsule, while its ventral and dorsal sides connect directly with the mandibular condyle. This means that the disc can follow the condyle in all its movements. Dorsaly the disc continues into a thick layer of loose and vascularized connective tissue, which fuses with the posterior wall of the articular capsule, the retrodiscal pad.

Vascularization

— The facial blood supply of the rat takes place through the branches of the external carotid artery. One branch, the facial artery, arises at the angle of the mandible, slightly dorsal to it and initially follows the lower edge of the masseter muscle. The external carotid artery continues in a cranial direction along the ascending ramus of the mandible and slightly dorsal to it. From this segment, branches extend to the ear, and thicker branches to the masseter muscle. At the level of the neck of the mandible the external carotid bifurcates into the maxillary and the superficial temporal artery, the latter being the larger of the two branches.

The maxillary artery

— Taking a course medial to the mandibular condyle over a short distance, this artery then divides into several branches which supply the masticatory muscles and the temporomandibular joint with blood.

Superficial temporal artery

— This artery takes its course lateral to the condyle roughly parallel with the zygomatic arch, towards the orbit. This vessel also produces branches extending to the temporomandibular joint. This joint is supplied with blood by small vessels directly derived from the above mentioned arteries or through the vessels of the enclosing musculature.
— The arteries destined for the articular disc and the condyle originate from the arterial vascularization of the capsule (Boyer *et al.* 1964; Hulke & Castelli 1965; Boyd *et al.* 1967). From the insertion of the capsule the vessels enter the disc to supply its peripheral part. Its central part, however, seems to be avascular (Bernick 1962).
— Arteries also enter the condyle from the insertion of the capsule on the mandibular condyle (Hulke & Castelli 1965). These vessels extend in the direction of the cartilage lining the condyle. Close to the cartilage, the vessels divide into a number of capillaries, each of which extends seperately to a part of the erosive zone of the cartilage. The capillaries penetrate the erosive zone to a depth of 3-4 cells beyond the bone-cartilage boundary (Durkin *et al.* 1969). The remainder of the cartilage is avascular. So far as could be established, the vascularization of the remaining cartilage in the temporomandibular joint has not hitherto been described. It is therefore reasonable to assume with Durkin *et al.*

(1969) that the metabolism of the cartilage, particulary that of the proliferative and the intermediate zone, utilizes the same medium as in other joints, namely the synovial fluid (Bauer *et al.* 1940). The same can be assumed for the nutrition of the central, avascular, part of the articular disc.

Efferent venous flow

— The blood collects in venules which unite to form larger veins. These relatively large vessels arise in the condylar process (Hulke & Castelli 1965), and probably anastomose with veins originating from the periosteum of this process. As the veins become larger, their course becomes more orles parallel with that of the corresponding arteries.

Surgical anatomy

— Apart from the anatomical structures already described, the following structures on the lateral side of the temporomandibular joint are of importance.

1. The cutis and the platysma. The platysma is a plate-like muscle which in young animals is not fully developed, but becomes thicker with increasing age.
2. The extra-orbital lacrimal gland.
3. The three branches of the facial nerve medial to this lacrimal gland. The upper branch is roughly parallel with and slightly cranial to the zygomatic arch. The middle (buccal) branch is likewise parallel with but slightly caudal to the arch. The lower branch (inervating the lower lip) virtually extends at the level of the mandibular edge. Slightly cranial to and parallel with this third branch, the parotid duct takes its course. The parotid gland is located immediately below and slightly behind the external auditory meatus.

HISTOLOGY OF THE MANDIBULAR CONDYLE IN THE RAT

— If microscopic changes in the condyle are to be studied, then the normal microscopic features of the condyle should be thoroughly familar. — For this purpose we have chiefly referred to publications by Levy (1948), Cunat *et al.* (1956), Öberg (1964) and Duterloo (1967). The experiments to be described were carried out in animals of an age at

which the mandibular condyle has developed its adult structure. Histologically, one can distinguish :
1) a cartilagenous and 2) an osseous part.

1. Cartilage

— The cells of the cartilage lining the condyle are divided into layers, otherwise known as zones. From the articular surface down to the bone, one can distinguish :
a. the articular zone;
b. the proliferative zone;
c. the intermediate zone;
d. the zone of hypertrophic cells;
e.the erosive zone.

a. *The articular zone*

— This is the most superficial zone; its thickness is virtually the same throughout : 4-5 cell layers (Blackwood 1966). This zone consists of fibroblasts and is subdivided by some authors into a superficial, highly cellularized, and a deeper, more fibrous and less cellularized layer. The boundary between the articular zone and the proliferative zone is clearly defined.

b. *The proliferative zone*

— This is also called the zone of pre-chondroblasts — a designation which indciates the function of this zone. The cells are flattened, but slightly more rounded and evidently larger than those of the articular zone. The long axis of the cell is oriented parallel with the surface of the condyle. There is relatively little intercellular substance. This zone in its totality is thinner in its ventral than in its dorsal part. Mitoses are frequant, the axis of cell division being paralel with the surface.

c. *The intermediate zone*

— In this zone, nuclei as well as cells are more oval-shaped and larger than the cells in the preceding zone. There is more intercellular substance. The zone is about as thick as the proliferative zone, and again the ventral part is thinner than the dorsal part.
— The occurrence of mitoses in the vicinity of the layer of hypertrophic cells is still a controversial subject. It is all the more difficult to reach a

conclusion in this respect because the histological boundary between the two zones is not clearly defined.

d. *The zone of hypertrophic cells*

— Together with the erosive zone, this zone is also known as the zone of cartilage. Its structure is typical of hyaline cartilage. The cells are large and rounded, with round nuclei and, unlike those in the preceding zone, separated by thick septa of intercellular substance.

— In contrast with the epiphyseal discs of the long bones, the cells in this zone are not arranged in columns. This zone is thicker than the abovementioned zones, its thickness gradually increasing from the ventral to the dorsal part. With the approach to the transition from cartilage to bone, the cells become larger and the nuclei more irregular in shape. This zone gradually merges with the erosive zone.

e. *The erosive zone*

— This is characterized by great celluar activity. The cavities in which the chondrocytes were sealed, are opened here. An invasion of undifferentiated mesenchymal cells and capillaries is visible. Calcification and osteogenesis take place here. Some remnants of calcified cartilage matrix are encapsulated here, and can later be identified as such deep in the bony condyle.

2. Bone

— At a greater depth, characteristic spongy bone with its typical trabecular structure is found. Osteoblasts are visible. Dependent on age, haemopoietic bone marrow can be found.

GROWTH OF THE MANDIBULAR CONDYLE

— Ageing is accompanied by changes in the macroscopic features, but especially in the histological structure of the condyle.

— In order to ensure a better understanding of the experiment. Some important data from the literature on changes in growth rate, macroscopic and microscopic features have been collected.

Growth rate

— The daily growth rate of the rat in general and that of its mandible in particular has been studied by Hughes & Tanner (1970). They produced growth curves which showed that the rate of growth of the rat gradually diminished during their period of observation. This gradual diminution was twice interrupted: the first interruption was between the 35th and the 39 th day post partum, and the second was between the 51st and the 55th day. During these interruptions, however, no increase in growth rate was observed as it has been observed in other animal species. The growth rate remained constant during these periods. Litle further growth was observed in rats older than 65 days.
— Nevertheless, the above mentioned authors did establish significant growth at the end of their experiment (110 days after birth).
— According to Vaughan (1943), Collins *et al.* (1946), Levy (1948) and Weinmann & Sicher (1955), the condyle retains its ability to grow until a very advanced age. Under certain circumstances growth can be reactivated e.g. with somatotropin.

Macroscopic features

— The surface of the mandibular condyle initially has a transverse oval shape, but after the 20th day post partum it begins to flatten (Furstman 1966).

Microscopic features

— With increasing age, the structure of the condyle changes, the changes involving the cartilage as well as the underlying bone. These changes are in general characteristic of a given period of life.

Cartilage

— During the first few days after birth, the mandibular condyle is almost entirely cartilaginous. The thickness of the cartilage rapidly diminishes with increasing age. In advanced age, the cartilage lining the condyle is still present, but in a greatly reduced amount. At the same time the zonal division is altered. Blackwood (1966) mentioned that in 6-week-old rats the thickness of the cartilage lining is reduced to an average of 25 cell layers, of which 5 belong to the articular zone,

10 to the proliferative and the intermediate zone, and 10 to the zone of hypertrophic cells and the erosive zone together.
— According to Collins *et al* (1946) the cells of the intermediate and the hypertrophic zone in 45-day-old rats are already smaller than those in corresponding zones in younger animals.
— Furstman (1966) reported that at about the same age the thickness of the erosive zone amounts to 1-2 cell layers, and that the zonal division of the cartilage is till unchanged by the age of 60 days.
This division is no longer distinct after the 4th month. The articular and proliferative zones are virtually unchanged at this age, but the hypertrophic and erosive zones have greatly diminished in thickness. Moreover, the cells of the latter two zones seem to intermingle to some extent.
— By the 10th month the intercellular substance, although its total thickness has remained about the same as that in 4-month-old animals, has increased in amount at the expense of the number of cells. These senescent changes continue in the same manner as the animal's age increases.

Bone

— According to Collins *et al* (1946), the number of capillaries at the level of the erosive zone begins to diminish at an age of 30 days. The haemopoietic bone marrow comes closer to this zone, whereas in younger animals this region is mostly characterized by capillaries and osteoblasts.
— According to Furstman (1966), the trabeculae are parallel to the ascending ramus of the mandible. The trabeculae are separated by large spaces filed with bone marrow.
— At an age of 40 days, the amount of bone has increased, and the spaces between the trabeculae have diminished as compared with those in one-month-old animals (Furstman 1966). Consequently, contact between bone marrow and cartilage is reduced
— According to Furstman, vascular elements are in contact with the cartilage at only a few sites in 72-day-old animals, in whom the thickness of the bone trabeculae has increased The condyle then consists mainty of bone. Haversian systems are regularly found at this age.
— Only incidental bone marrow spaces are still visible at the age of 6 months
— The changes so far described continue with increasing age. Nevertheless, osteoblasts are occasionally found at the boundary between cartilage and bone, even in specimens of advanced age.

Conclusion

— Maximal growth of the mandibular condyle in the rat occurs between the 30th and the 60th day post-partum. In view of the fact that the proliferative zone persists until advanced age, re-activation of the condylar growth cannot be excluded even in older animals.

CHAPTER V

EXPERIMENTAL OPERATIONS

INTRODUCTION

— The survey of the literature, the conclusions and the description of the anatomy, physiology and growth of the mandibular condyle as presented in the preceding chapters, warrant the following hypotheses on the effects of a traumatic lesion in the context of this study;

a. the lesion causes vascular disorders of the mandibular condyle, resulting in its hyperplasia;
b. the lesion gives rise to hyperplasia by direct damage of articular components;
c. the lesion causes periarticular and intra-articular haemorrhage and oedema, the local tissue reactions then resulting in hyperplasia.

— This chapter discusses several operative methods, each of which was used to test one of the abovementioned hypotheses on posibilities to provoke hyperplasia. All operations were performed on the left temporo-mandibular joint. The results obtained were compared with findings on the intact, right, condyle and with the findings obtained in controls

MATERAL AND METHODS

— Male rats aged 56 days were used in the experiments According to Hughes & Tanner (1970), the pubescent growth spurt in the male rat ends at this age. The total number of rats used was 58. Of these, 30 were divided into 5 test groups of 6 rats each (groups I, II, III, IV and V). In addition, 6 rats were submitted to a so-called sham operation (group VI). A total of 22 rats served as controls for the various test groups. The condyles which were damaged during the extirpation of the jaws are not mesured.

Group I

— Temporary interference with the efferent venous flow was effected in this group. For this purpose the efferent venous flow in the condyle of the mandible was interrupted by drilling a hole in the condylar process.

Operative technique

— Once the ascending ramus of the mandible is exposed (see Chapter IV), a careful approach is made to the notch (a) between the coronoid and the condylar process and the notch (b) between the condylar process and the angle of the mandible (Fig. V1). For this purpose the masseter muscle is

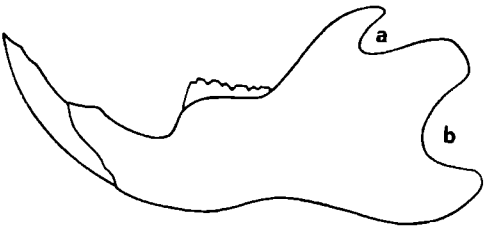


Fig V 1 See the text.

stripped off the ascending ramus. From the subcondylar notch (b), an Ash 6 is pased through the pterygomandibular space in the direction of notch (a). This ensures fixation of the ascending ramus and also protects the tissues of the pterygomandibular space from inadvertent drilling damage.
— Next, a Hyatt bur is used to drill an oval immediately below the neck of the mandible, with the smaller diameter parallel with the condylar process. The medial cortical layer of the ramus is similarly perforated. The ventral and dorsal edges of the condylar process remain intact.
— No attempt is made to close the bone defect. The lesion resulting from the operation could be regarded as a fracture of the condylar process, but without dislocation and with the continuity of the process remaining intact.

Group II

— Interference with the arterial blood supply was effected in this group by stripping part of the articular capsule off the neck of the mandible.

Operative technique

— After the approach to the ascending ramus (see Chapter IV), an Ash 6 is used to locate the notch between the condylar and the coronoid process. Working from the ventral aspect, on-third of the articular capsule is stripped away both on the medial and on the lateral side.

Similarly, one-third of the fasciculi of the external pterygoid muscle is stripped away from the ventral part of the neck of the mandible.
— The cranial articular compartment remains closed. The tissues are then restored to their original position, and sutured.

Group III

— In this group, interference with the efferent venous flow as well as with the arterial blood supply was effected by combining the two procedures described for group I and group II, respectively.

Group IV

— In this group, a haemorrhage was produced in the cranial as well as in the caudal articular compartment (haemarthrosis).

Operative technique

— Once the ascending ramus of the mandible is exposed two spring clamps are applied, one on the ventral and the other on the dorsal side. One arm of each clamp is placed beneath the zygomatic arch, while the other arm is placed between the ascending ramus and the masseter muscle. In this way the operative wound is kept open while at the same time caudal traction is exerted on the ascending ramus. Consequently the condyle of the mandible moves to another level, more caudal, than the lateral wall of the mandibular fossa. The articular disc follows the condyle, and as a result the cranial articular compartment is enlarged. The tissues beneath the zygomatic arch are then incised deeper and the cranial articular compartment is opened. This incision is made in a dorso-ventral direction to avoid the large vessels immediately dorsal to the condylar process.
The caudal articular compartement is opened by incising the capsule from the lateral side and the articular disc is carefully moved medially. The two articular compartments then fill with blood from the adjacent tissues. Next, the articular disc is restored to its original position, and the wound is closed.

Group V

— Extirpation of the articular disc was performed in this group.

Operative technique

— The cranial articular compartment is opened as described for group IV. Fixation of the disc against the condyle is effected with the aid of a pointed retractor, and a mediolateral incision is made on the dorsal side of the disc. Next, the retractor is placed in the incision, the disc is lifted and is extirpated using the tip of the blade. The wound is then closed.

Group VI

— A so-called sham operation was performed in this group; this was done in order to study the influence of the operation per sé (e.g. incision, oedema, etc.) in terms of possible hyperplasia.

Operative technique

— Once the ascending ramus is reached (see Chapter IV), the two notches and the insertion of the articular capsule on the neck of the mandible are identified. The wound is then closed.

Controls

— The controls were anaesthetized, and the hair on the left side of the face was clipped. Further management and care were the same as for the test animals.

END OF EXPERIMENTS

— The duration of the experiments was 16 days, as previously mentioned. On the 16th day after operation, the animals were sacrificed by increasingly deep ethre anaesthesia. The mandible was immediately dissected, prepared, and fixed in a 4 % solution of neutral formalin. A few days later the mandibles were photographed in a standardized manner from a cranial and a lateral view. These photographs were used in measuring various dimensions.

a. *Cranial photograph*

— For the cranial photograph the sagittal axis of the condyles was oriented horizontally. Prints were made on paper of conventional dimen-

sions (9 x 12 cm), the factor of magnification of the print being 13.9. Measuring was done with the aid of Koikhaus caliper and a gauge ensuring 0.1 mm accuracy. Three tracings of the contours of the condyles were obtained from each cranial photograph and distances were measured from these tracings. Per variable, it was considered sufficient to measure each tracing once. The following variables were thus measured in triplicate .

1) the length of the largest sagittal axis of the condyle : condylar length;
2) the length of the largest transverse axis of the condyle ·

b. *Lateral photograph*

— The mandibles were then divided at the symphyses and lateral photographs were taken of the two halves. Measurements were made in triplicate directly from the prints, which had a factor of magnification of 2.38. The one variable measured was the height of the ascending ramus of the mandible · ramus height (diag. V1).

Statistical analysis

— The basic value used in the statistical analysis was the mean of triplicate measurements. As previously mentioned, the test groups were indicated by the numerals (I through VI), while the control groups were indicated by the letters A through D.

— The large number of animals to be operated on made it necessary to carry out the experiments in four phases For each phase a control group was available. The supply of animals was such that the four control groups were not comparable to begin with. Within each phase, however, the animals were divided at random into controls and test animals. This means that the groups can be compared only within each phase, the following four sets of groups thus being available : B-I; D-II; C-III-VI; A-IV-V.

— Before discussing the results of measurements, it should be pointed out that the purpose of the analysis presented in this chapter is to establish whether the above mentioned operations resulted in a distinct difference between the left and the right condyles, and, if so, which procedure produced the most marked difference.

Results

— The test results are expressed with the aid of tail probabilities, using the following symbols and interpretations.

Tail probability	*Symbol*	*Interpretation*
P>0.10	NS	not significant
0.05<P<0.10	(*)	significance suggested
0.01<P<0.05	*	significant
P<0.01	**	highly significant

— A summary of the measurements obtained is presented in table V1.

Table V.1 : Mean (x) and standard deviation (sd) of condylar length and width and ramus height; unit used : 10^{-1} mm.

Group symbol		Condylar length left	Condylar length right	Condylar width left	Condylar width right	n =	Ramus height left	Ramus height right	n =
B	x	33.8	34.1	15.9	15.9	4	109.5	108.5	5
	sd	0.8	0.8	0.4	0.4		6.3	5.9	
I	x	34.3	33.9	16.4	16.6	5	110.6	108.4	6
	sd	0.8	1.4	0.7	0.8		6.0	6.1	
D	x	34.3	34.2	16.5	16.5	4	111.1	111.3	6
	sd	0.6	1.1	0.3	0.2		2.3	1.6	
II	x	33.8	33.8	16.4	16.4	6	108.1	107.3	6
	sd	1.4	0.9	1.1	1.0		3.1	3.2	
C	x	34.0	34.1	16.2	16.1	2	108.1	106.7	5
	sd	1.0	0.6	0.6	0.6		2.6	3.5	
III	x	33.3	34.0	15.3	16.0	6	106.3	107.9	6
	sd	1.3	0.9	0.6	0.6		3.2	2.1	
VI	x	34.7	34.6	16.2	16.2	5	110.5	108.6	6
	sd	0.3	0.5	0.6	0.7		2.2	3.2	
A	x	35.0	35.1	16.3	16.4	4	110.1	109.8	6
	sd	0.6	0.5	0.7	0.8		4.4	4.1	
IV	x	33.6	33.9	16.1	16.2	5	108.1	107.2	5
	sd	1.1	0.9	0.6	0.2		3.1	2.6	
V	x	35.3	33.6	19.9	15.8	5	110.3	106.3	5
	sd	1.5	1.7	1.7	0.8		0.8	1.3	

— The distances primarily measured are tabulated here, after multiplication by $\frac{1}{b}$ (in which b = standard of representation) to convert them to true size.

— Each figure indicates the mean of three measurements of the anatomical substrate with 0.1 mm accuracy. The table is intended as a summary of the distribution of each variable in each group of animals.

— On the basis of this table, it is not allowded to compare the groups or to compare left with right condyle in order to assess the effect of the operation. As a measure of the relativ left right difference in development between left and right condlye, we used the magnitude

$$h - \frac{X_L - X_R}{X_R}$$

— This magnitude will henceforth be used to indicate relative hyperplasia in relation to magnitude X. The occurrence was investigated in each group. It has to be remarked that relative left/right difference as difined by $h = \frac{X_L - X_R}{X_R} * 100$ is not a symmetric measure, it measures the difference between left and right relative to the right.

When the left and right are symmetrical the mean relativc left/right difference is in fact greater than zero.

So strictly speaking a mean relative left/right difference h greater than zero, don't need to be interpreted as a difference between left and right; especially when the mean relative left/right difference is small or the absolute value of the difference between left and right is large compared with the x-value. It is also not allowed to compare the mean relative left/right difference with the variables.

However this measure is commonly used to indicate a relative effect and this convention is followed.

In the analysis an operation effect is not based on a mean hyperplasia greater than zero in the experimental and control groups.

This method gives a possiblity to detect operation effects and to quantify the results in a conventional way.

Besides, this relative measure accounts for different starting values in the groups.

The Student one-sample test was used to establish — per group and per variable — whether the mean-hyperplasia differed significantly from O. In the analyses two-sided statistical tests are — performed (table V2).

Table V 2 Mean relative left/right differences (h) as to condylar length and width, and ramus height, with levels of significance * (one-sample Student test)

Group	Condylar length			Condylar width			Ramus height		
	h (%)	sd	p-value	h (%)	sd	p-value	h (%)	sd	p-value
B	—0.9	0.2	**	0.3	2.0	NS	0.9	0.7	*
I	1.5	2.3	NS	—1.2	3.2	NS	2.0	0.6	**
D	0.5	1.7	NS	0.2	1.2	NS	—0.2	1.2	NS
II	0.1	2.1	NS	0.2	1.1	NS	0.8	0.7	(*)
C	—0.4	1.3	NS	0.2	0.1	NS	1.4	2.5	NS
III	—2.1	1.6	*	—4.4	4.8	(*)	—1.5	2.0	NS
VI	0.0	0.7	NS	0 1	1.7	NS	1 7	2.4	NS
A	—0.3	0.4	NS	—0.5	1.5	NS	0.2	0.5	NS
IV	—0.8	1.0	NS	1.5	3 0	NS	0.9	3.6	NS
V	4 8	2.1	**	26.1	15.7	*	3 7	0 9	**

* In the above and the following tables p-values means « the level of significans as indicated op p 46

— This table persents the relative of the left/right differences per group and per variable. A striking feature is the mean hyperplasia in group V in relation to condylar width. It is also quite conspicuous that group V shows the most marked unilateral hyperplasia in relation to the three variables studied.

— The three control groups D, C and A, and the sham operation group (group VI) don't show significant difference. Control group B shows a different pattern · the significant negativ difference in condylar lenght between left and right in this group must probably be ascribed to imperfections in dissection of the mandibles. Another outstanding finding is the relative left/right difference revealed by measuring condylar length in test group III, in which group there are also indications of a significant shortening of the transverse axis.

— Finally, mention should be made of the increased ramus height in test group I.

— Whether the difference in the test groups can be attributed to the operative technique, depends on the degree of difference (if any) in development between the left and the right condyle in the corresponding control groups. As mentioned, an operative effect on the above defined hyperplasia, although it seems present, should be measured by direct comparison with the corresponding control group.

— Within each set, efforts were made to establish whether the groups in the set showed significant differences (per variable) in mean of relative values (analysis of variance). The tail probabilities computed are presented in table V 3A.

Table V 3A Operative effects within each set on the basis of mean (relative) differences (h) Analysis of variance

Group	Condylar length			Condylar width			Ramus height		
	n	h (%)	p-value	n	h (%)	P-value	n	h (%)	P-value
B	4	—0.9	*	4	0.3	NS	5	0.9	**
I	5	1.5		5	—1.2		6	2.0	
D	4	0.5	NS	4	0.2	NS	6	—0.2	NS
II	6	0.1		6	0.2		6	0.8	
C	2	—0.4		2	0.2		5	1.4	
III	6	—2.1	(*)	6	—4.4	NS	6	—1.5	(*)
VI	5	0.0		5	0.1		6	1.7	
A	4	—0.3		4	—0.5		6	0.2	
IV	5	—0.8	**	5	1.5	**	5	0.9	*
V	5	4.8		5	26.1		5	3.7	

— The overall impression gained from this table is in accordance with what could be expected from table V2. The hyperplasia of the condylar length in the groups B and I is probably due to imperfections of dissection. The difference in mean ramus height posibly represents an operative effect.

— No indications of an operative effect are found in set D-II.

— In set C-III-VI, the hypoplasia of condylar length in group III is reflected only in an indication of an operative effect. In this set it is also apparent that a suggestion of significant hypoplasia of condylar width in group III as compared with control group and sham operation group, cannot be attributed to an operative effect.

The criterion for acceptance of an operative effect was the mean relative left/right difference between experimental and control group. Estimates of these effects (contrasts) with the corresponding tail probabilities (Scheffé P-values) are presented in table V 3B.

Table V 3B Estimated operative effects, comparing test group with control group within each set on the basis of mean relative differences (h) Analysis of variance.

Group	Contrast (%)	Condylar length estimate	Condylar length Scheffe p-value	Condylar width estimate	Condylar width Scheffé p-value	Ramus height estimate	Ramus height Scheffé p-value
I	$h_I - h_B$	2.4	*	—1.5	NS	1.1	**
II	$h_{II} - h_D$	—0.4	NS	0.0	NS	1.0	NS
III	$h_{III} - h_C$	—1 7	NS	—4.6	NS	—2.9	NS
VI	$h_{VI} - h_C$	0.4	NS	—0.1	NS	0.3	NS
IV	$h_{IV} - h_A$	—0.5	NS	2.0	NS	0.7	NS
V	$h_V - h_A$	5.1	**	26.6	**	3.5	*

— It is to be noted that, strictly speaking, the procedure of analysis of variance in set A-IV-V is debatable because the within-group variances in this set show fairly marked differences. The results in this set are so pronounced, however, that it is qualitatively justifiable to make formal mention of the analysis of variance.

— The overall impression which emerges from table V 3B is roughly in accordance with expectations.

— Operative technique I shows significant effects on condylar length and ramus height. It is doubtful whether the effect on condylar length is really an operative effect, but on the other hand the effect on ramus height may have been underestimated.

— Operative techniques II, IV and VI (sham) produced no demontrable effect; also in group III no operative effects could be fond.

— It is quite evident from this table that the operative technique used in group V produced the most marked and most significant effect on the three variables studied.

— If only increase of ramus height is required, then operative technique I can certainly be considered.

— However it was demonstrated that:

a) it is possible to produce hyperplasia of the mandibular condyle by surgical intervention (traumatic lesion);

b) according to table V 3B operative technique no V is to be prefered.

— Although hyperplasia of the condyle develops after extirpation of the articular disc, as mentioned above, the three variables do not all change to the same extent. Moreover, there were marked individual differences in the degree of hyperplasia observed.

Cranial view

— The most striking hyperplasia is shown in the cranial photograph · the hyperplastic condyle has lost its pear-shaped contours and assumed an ellipsoid shape. The mediolateral axis is generally most affected, and consequently the ratio between sagittal and mediolateral axis has become less than 2 : 1. The contours are regular. The articulating surface is smooth and slightly flattened. A cartilaginous lining is observed throughout

Lateral view

— In the lateral photograph, the sagittal axis of the articulating surface has a more horizontal orientation. The hyperplastic condyle, together with the neck of the mandible, gives a somewhat mushroom-like appearance to the condylar process.

DISCUSSION AND CONCLUSIONS

— For better interpretation, before discussing the operative techniques used, it seems advisable to make some general remarks on the experiments in their totality.

— An effect comparable with the effect of the interventions described cannot be produced by means of blunt violence upon the mental area. Operative trauma to the temporomandibular joint is necessary and this additions effects The number of animals to be operated on made it necessary to carry out the experiment in several phases. Comparison between the various test groups between phases was not justifiable.

— The information in the literature on stimulation or inhibition of the growth of the mandibular condyle particularly by surgical interventions, is minimal. The discussion must therefore refer to experiments carried out on long bones. In this respect it should be borne in mind that the anatomical and physiological features of the long bones differ in several aspects from those of the mandibular condyle

Intervention with efferent venous flow

— Several investigators have observed an increase in the length of the growing limb resulting from obstruction of the efferent venous flow. The methods used to achieve this often differed, and therefore the results could not be compared.

— Sevelle (1948) observed a significant increase in the length of a growing limb after total occlusion of the femoral veins. Colt & Iger (1963) reduced the lumen of the femoral veins by an operative technique, but the result in terms of hyperplasia was minimal. Hutchison & Burdeaux (1954) applied tourniquets and subsequently observed a constant increase in the length of the limb involved. Gulhuus-Moe (1969) fractured the condylar process of the mandible in young animals and observed that the number of mitoses in the growth area of the condyle showed an increase during a given posttraumatic period. The thickness of the zone of hypertrophic cells was likewise increased. These observations were interpreted as « an attempt of the condyle of the mandible to regain the lost length of the ascending ramus ». Sprinz (1967) was unable to demonstrate such changes after experimental fracture of the condylar process in adult rats. In all the experiments carried out by this author, there was shortening of the ramus as a result of the fracture of the condylar process.

— Our experiments imitated a « fracture » of this type in growing rats, but with our operative technique, the ramus height was not reduced. In our group I, there was a significant increase in the length of the ascending ramus as compared with the opposite side, and with the control animals, 16 days after the intervention. However, the dimensions of the sagittal as well as the transversal axis of the condyle remained unchanged. This result is in agreement with the observations reported by Gulhuus-Moe (1969). However, his conclusion that this result should be ascribed to loss of ramus height seems debatable in the light of our experiments.

Intervention with arterial blood supply

— In our study, no significant difference (either in a positive or in a negative sense) in condylar growth was observed after we had stripped part of the articular capsule and the external pterygoid muscle away from the neck of the mandible.

— Ferguson (1933), however, observed increased longitudinal growth of the femur after damaging its nutrient artery. It is possible that in his

procedure, reduction of the arterial blood supply to the growth plate of the bone in question, was accompanied by side-effects which may have been the true cause of the hyperplasia. In our experiments, moreover, it is possible that an insufficient length of capsule and muscle was stripped off. Another possibility is that the stripped part healed so rapidly that the factor « reduction of blood supply » was given insufficient time to exert any influence on condylar growth.

Simultaneous intervention with arterial blood supply and efferent venous flow

— In this part of our experiments, we obtained no hyperplasia. On the contrary we found indications that this combined intervention led to *inhibition* of condylar growth. Our results are in agreement with those reported by Brookes (1957), who was able to demonstrate femoral shortening after severing the nutrient artery and vein in the nutrient foramen and closing the latter with fragments from the adjacent bone. He suggested that this inhibition of growth resulted from obstruction of the arterial blood supply rather than from its combination with obstruction of the efferent venous flow.

— In our experiment, however, neither intervention with the arterial supply nor intervention with the efferent venous flow produced any separate result — assuming — that the anatomical data presented by Hulke and Castelli (1965) are reliable. When we combined the two interventions, we found indications of possible inhibition of the growth of the condyle involved. The animals thus treated showed marked individual differences in the degree of hypoplasia, but these differences may have resulted from inadequate standardization of the operative technique used. Further investigation on these lines will, we trust, yield more constant results and give a better insight into the factors which play a role in stimulation of endochondral bone growth in general.

Extirpation of the articular disc

— All rats which, in our experiments, underwent extirpation of the articular disc showed unmistakable hyperplasia of the mandibular condyle. We observed both sagittal and transverse hyperplasia of the condyle and an increase in the length of the ascending ramus (fig. V2). The hyperplasia was most marked in the transverse axis of the condyle, less marked in the sagittal axis, and only moderate in the height of the ramus. As to this last point it is possible that the operation has influenced the growth of the opposit condyle; there is an indication that the height of the opposit

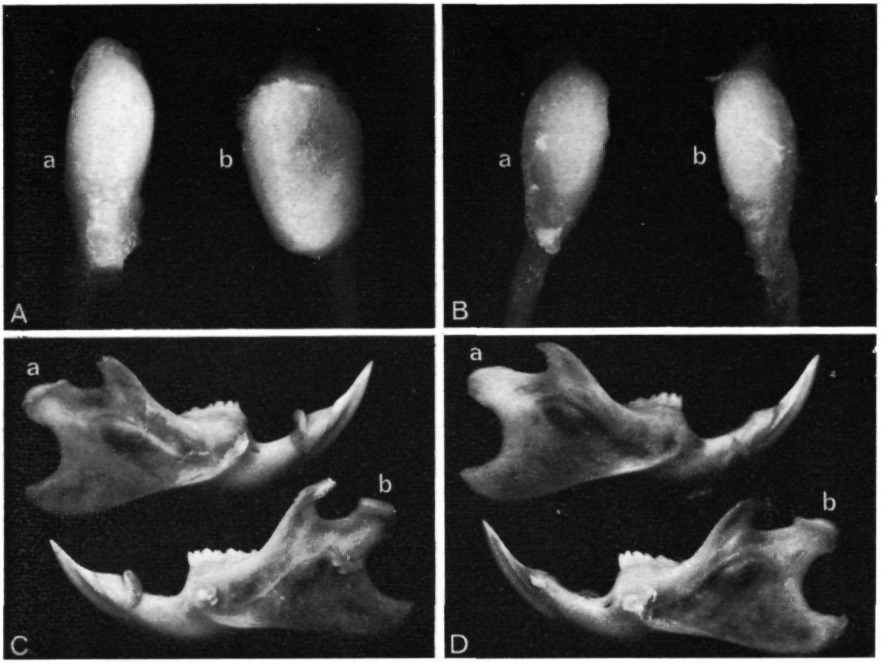


Figure V.2. A. B. C. D.
Compare :
— Condyles and ascending ramus of the test animals (A, C with those of the control animal (B, D.
— The test side (Ab, Cb with the intact side (Aa, Ca.
Magnificaiton A and B 8x
Magnification C and D 1,6x

ramus is less in the experimental group than the height of the ramus in the controle group.

These results largely agree with those reported by Sprinz (1954), who demonstrated in rabbits that the surface area of the condyle had increased after extirpation of the disc.

— Dubecq (1937), however, did not mention hyperplastic condyles in connection with a similar operation; he may have overlooked this point because he was probably so absorbed by the problems of crepitation in the temporomandibular joint, that he gave insufficient attention to condylar hyperplasia (which according to our findings must have existed in his animals).

— Although the dimensions of the hyperplastic condyles in our experiments varied, their surface was smooth and their contours regular. In this

respect our findings are in agreement with those reported by Dubecq (1937).

— In a number of the animals described by Sprinz (1954), however, the articular surface of the condyle was uneven and nodular, and the contours were irregular. Sprinz mentioned as a possible cause that damage was inflicted to the condylar surface during extirpation of the articular disc.

— Neither in the experiments of the abovementioned authors nor in our experiments was regeneration of the articular disc observed.

CHAPTER VI

EXTIRPATION OF THE ARTICULAR DISC

— It has been demonstrated in the preceding chapter that it is possible to produce hyperplasia of the mandibular condyle by operative techniques described therein. In particular, extirpation of the articular disc at the end of the growth period proved to cause this hyperplasia.

— It is hardly conceivable, however, that the articular disc can be made to disappear by blunt violence on the mandible. It seems more likely that such violence causes a partial lesion of the articular disc.

PROBLEM STATEMENT

1. Does partial extirpation of the articular disc lead to hyperplasia of the condyle? If so, then the hyperplasia thus effected will be compared with that obtained after total extirpation of the articular disc.
2. How does the remainder of the articular disc behave after partial extirpation? Can a disc in which a small or a large defect has been produced, show total or partial regeneration or does the defect retain its original shape and size?
3. Is bilateral total extirpation of the articular disc followed by uniform hyperplasia evenly distributed over both condyles?
   An answer to this question will reveal whether or not local factors influence the effect of extirpation of the disc.

MATERIAL AND METHODS

— In experiments carried out in order to answer the above questions, 29 rats were used. They were of the same age and sex, and their general accommodation and care was the same as described earlier. The animals were divided into four test groups marked with the numerals I through IV. For better comparison of groups I and II and for statistical analysis of the values measured, a control group of 5 animals was added.

Group I

— This group consisted of 5 rats submitted to total extirpation of the left articular disc as described in chapter V (Fig. VI.1).

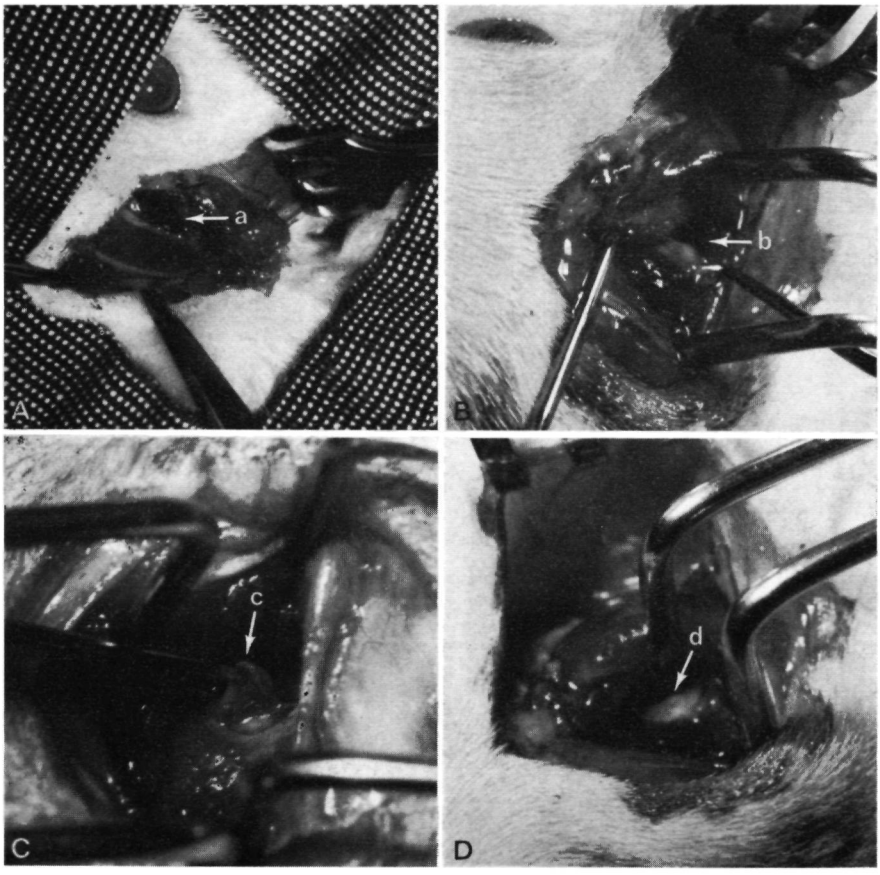


Figure VI.1. Extirpation of the articular disc.

A. Incision of the skin and identification of the branches of the facial nerve. Incision of the masseter muscle immediately above the second branch (a).

B. Opening of the cranial compartment of the joint. Cranial aspect of the articular disc (b).

C. The insertion of the disc has been incised from the dorsolateral side. The disc itself has been lifted with the retractor (c).

D. Condition after excision of the articular disc. The exposed condyle (d).

Group II

— In this group of 5 rats, partial extirpation of the left articular disc was performed. The part extirpated was a circle sector which accounted for one-fourth to one-half of the total disc surface area (Fig. VI 2.1).

Technique

— The cranial compartment of the joint is opened and the cranial surface of disc is exposed, as described in chapter V. A triangular incision is then made form the centre to the periphery, and the above mentioned sector is removed. The underlying condylar cartilage is left untouched.

Control group

— This group encompassed 5 rats kept under the same conditions as those in groups I and II, but not submitted to operation.

Group III

— The 9 rats of this group were divided into three sub-groups of 3 rats each, called a, b and c. The fragment of articular disc extirpated in these animals was always smaller than one-quarter of the total surface area.

a. In this sub-group a segment was extirpated from the dorsal part of the disc; the cord subtending this segment parallelled the transverse axis. The central part of the disc was not involved in this operation (Fig. VI 2.2).
b. In these 3 rats the central part of the disc was extirpated, the exitrpation again involving less than one-quarter of the total surface area. The periphreal parts of the disc were left intact in this sub-group (Fig. VI 2.3).
c. In the animals of this sub-group the so-called retrodiscal pad (see chapter IV), was removed, thus creating a communication between cranial and caudal compartment. Although the retrodiscal pat is not, strictly speaking, part of the articular disc, this intervention was brought under the heading of test group III (Fig. VI 2.4).

Technique

— The incision is made along the dorsal edge of the disc, in the transition to the retrodiscal pad. The latter is then removed with part of the

tissue localized dorsal to it, thus creating a communication between the cranial and the caudal articular compartment.

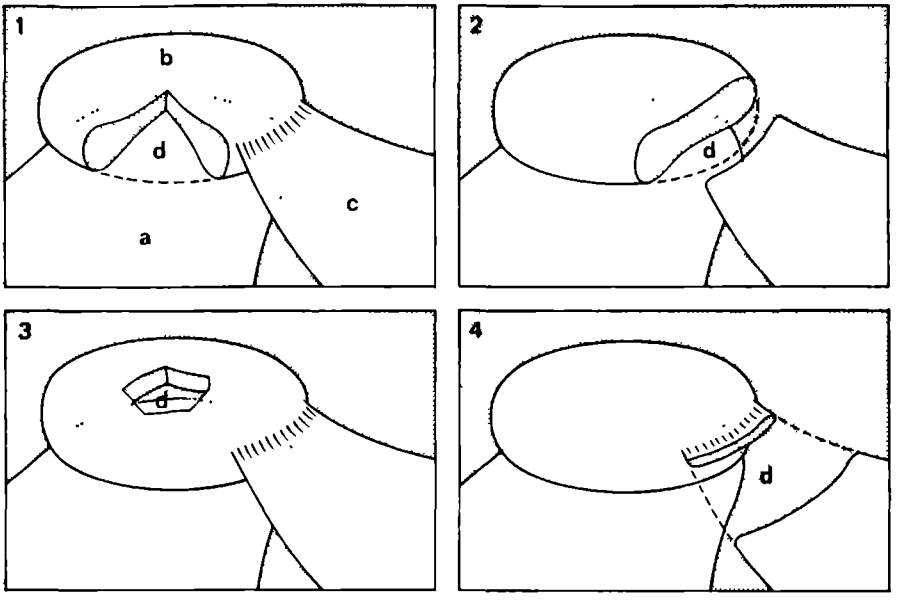


Figure VI.2. Schematic representation of the partial extirpations performed. For their descriptions, see the text.
a. Condyloid process.
b. Articular disc.
c. Retrodiscal pad.
d. Operative defect.

Group IV

— This group consisted of 5 rats submitted to bilateral extirpation of the articular disc.
— In groups I and II the defect was photographed during the operation for subsequent comparison with postmortem findings.

END OF THE EXPERIMENT

— All animals were sacrificed 16 days after the operation, as described in chapter V. The mandible was removed and the defect in the disc photographed again. All mandibles were kept in the conventional neutral formalin solution.

Measurements

— The Optocom was used to measure the mandibles from groups I and II as well as those from the control group. The Optocom is a microscope fitted over a two-dimensionally moving stage. The factor of magnification of the microscope is 10. The depth of field without adaptation is 5 mm. The microscope is also equipped with a cross-hair reticle.
— The two dimensionally moving stage is used to bring a given point into the focus of the cross-hair reticle, whereupon the coordinates of this point are electronically recorded by pushing a button (the technical data on the Optocom are described by Van der Linden *et al.* (1972).
— Each condyle was measured in the cranial, and each ascending ramus in the lateral, view. Measurements were made in duplicate, a third measurement being unnecessary in view of the precision of the Optocom and the degree of hyperplasia. Measurements in the cranial view were taken directly from the condyles, while those in the lateral view were taken from the radiographs. The data of the measurements in the lateral view are thus reffered only to the lenght of the bony ramus.

Measurements in the cranial view

— For these measurements the mandibles were fixed to the Optocom stage in such a way that the sagittal axis of the condyle was oriented as horizontally as possible.

Measurements in the lateral view

— After measuring in the cranial view, the mandibles were divided at the symphysis. The so-called « séinograph » was used to obtain comparable radiographs of the two halves, which for this purpose were placed with the lateral surface flat on the film, the tube being kept vertical at a constant distance of 20 cm over the film.
— The seinograph is a roentgen apparatus which emanates a monochromatic X-ray beam, making it possible to obtain highdefinition radiographs of low-contrast objects.

Microscopic examination

— After measurements the hyperplastic condyles were histologically examined. Sections were cut in sagittal as well as in transverse direction. Simultaneously, similar sections were cut from the contralateral

condyle. For better comparison, only the most central sections were studied. The sections (7-10 μ thick) were submitted to :

1) haematoxylin-eosin staining,

2) Van Gieson staining.

— The stains were made in the conventional manner as described in, for example, the Laboratory Guide of Schillings and Haan (1964).

RESULTS

Problem 1

— Table VI.1 summarizes the measurements made in test group I (total extirpation · TF), test group II (partial extirpation : PE) and the control group (C).

Table VI 1 Mean (x) and standard deviation (sd) in 10^{-1} mm, per variable studied, per group

Treatment		Condylar length left	Condylar length right	Condyar width left	Condyar width right	Ramus heigt left	Ramus heigt right	n =
Group C	x	31.0	32.0	16.3	16.5	107.6	106.8	5
	sd	2.3	1.0	1.5	0.8	2.7	2.3	
Group PE II	x	37.8	32.4	22.2	17.8	106.6	103.7	5
	sd	3.6	3.5	1.9	1.3	3.0	2.8	
Group TE I	x	35.6	31.8	23.6	17.4	107.4	107.0	5
		4.4	2.3	1.8	1.1	4.9	4.2	

— Table VI.2 presents the mean and standard deviation of the left/right differences of each of the three variables studied. It also indicates whether the differences established were significantly different from (larger than) O. The results of the Student one-sample test (t-test) used for this purpose are presented in the column « t-test ».

— It is evident that hyperplasia of the left condyle occurred after PE or TE.

a). That partial extirpation did lead to hyperplasia of the left condyle is apparent from a comparison of group C with group PE with regard to the corresponding variables in table VI.2.

Table VI.2 : Mean and standard deviation of relative left/right differences of the left as compared with the right mandible, and results of the Student one-sample test (t-test) applied to h.

Treatment		Condylar length hyperpl. %	t-test	Condylar width hyperpl. %	t-test	Ramus height hyperpl. %	t-test
Group C	h	—2.8	NS	—1.2	NS	0.8	NS
	sd	8.0		9.9		1.5	
Group PE II	h	17.3	*	25.7	*	2.8	NS
	sd	13.2		17.0		3.3	
Group TE I	h	12.0	(*)	36.8	*	0.4	NS
	sd	10.9		18.7		2.1	

— It can be concluded from this table that partial extirpation leads to condylar hyperplasia. In terms of ramus height, however, no significant difference between groups C, PE and TE seems to be demonstrable ($P>0.10$ analysis of varience).

b). Comparison of the degree of hyperplasia caused by partial extirpation with that resulting from total extripation revealed no significant difference. The results of the relevant comparisons are also presented in table VI.3.

Table VI.3 :

Comparison of group C with group PE (from table VI.2).

α	h : differecne PE-C	Student test two-sample
condylar length	20.1 %	$t = 3.08$ $df = 8$ $P<0.02$
condylar width	26.9 %	$t = 3.06$ $df = 8$ $P<0.02$
ramus height	2.0 %	$t = 1.23$ $df = 8$ $P<0.20$

Comparison of group TE with group PE (from table VI.2).

β	h : difference PE-TE	Student test two-sample
condylar length	5.3 %	$t = 0.69$ $df = 8$ $P>0.40$
condylar width	—11.1 %	$t = 0.98$ $df = 8$ $P>0.30$
ramus height	2.4 %	$t = 1.37$ $df = 8$ $P>0.20$

— It can be pointed out, finally, that the three groups C, PE and TE did not significantly differ in contralateral condylar length and width. Nor was a significant difference in ramus height demonstrable between these three groups (simple variance analysis : $P>0.10$, $P>0.10$, $P>0.10$, respectively).

In this experiment the interventions probably exerted no influence on the growth of the contralateral condyle, and the hyperplasia observed after the intervention is therefore probably a direct consequence of the operation.

Problem 2

Restoration of defects of the articular disc

— No regeneration of the disc occured in the animals group III and those of group II which were submitted to partial extirpation of the articular disc. On the contrary : the operative defect showed an unmistakable increase in size.

— In all animals of group II in which, as described, a sector of the disc was extirpated, the postmortem examination showed that the defect had increased in size. The degree of disc degeneration proved to be dependent on the dimensions of the part originally excised : the larger the original exision the more the degeneration. For example, only a sickle-shaped fragment of the disc was found 16 days after extirpation of one-half of the disc (Fig. VI.3). Degeneration was relatively more limited after excision

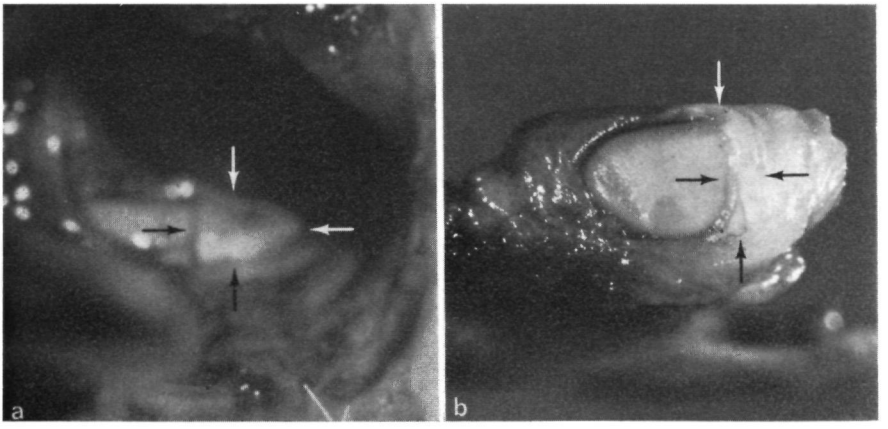


Figure VI.3. Excision of the ventral half of the disc.
a. During the operation.
b. After 16 days.
The arrows indicate the contours of the remaining disc at times a and b, respectively.

of smaller disc sectors. The length of the base of the sector generally remainted unchanged, and the defect consequently tended to change its shape from triangular to square (Fig. VI.4).

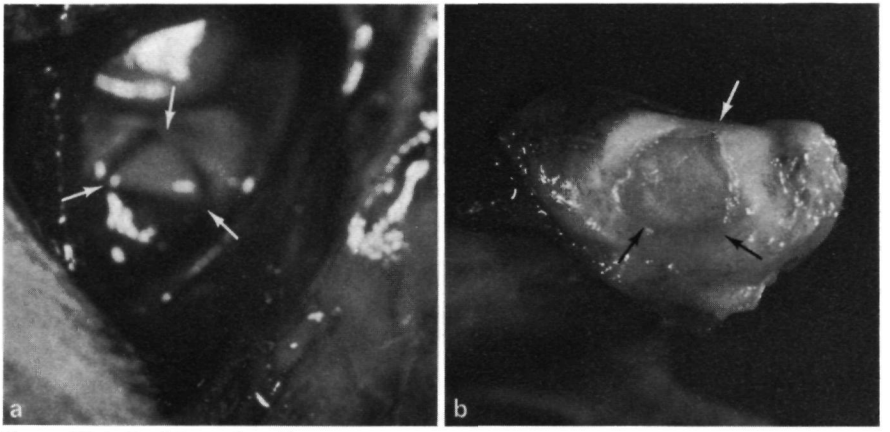


Figure VI.4. Excision of a disc sector.
a. During the operation (about a quarter of the total surface area).
b. Exten tof the defect after 16 days.

— The condyle of the mandible beneath such a disc was hyperplastic; its articular surface was smooth.

— In group III, the animals in each of the three subgroups showed different reactions to partial extirpation of the disc and excision of the retrodiscal pad.

a. Considerable postmortem degeneration of the disc was found in the animals in which a disc segment accounting for less than one-quarter of the disc surface was excised. The final defect corresponded to more than one-half of the total disc surface.

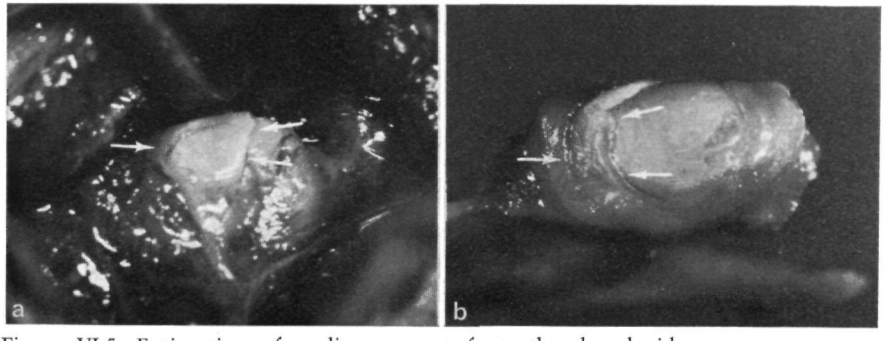


Figure VI.5. Extirpation of a disc segment from the dorsal side.
a. During the operation (less than a quarter of the total surface area).
b. Extent of the defect after 16 days.

The hyperplastic condyle had a smooth articular surface (Fig. VI.5).

b. In the animals in which a central part of the disc was extirpated, no restoration of the defect occurred; neither did further degeneration of the disc occur. The size of the defect remained about the same (Fig. VI.6).

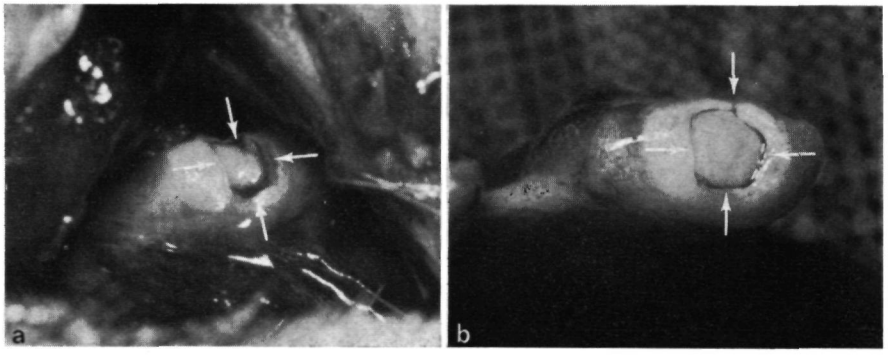


Figure VI.6. Excision of a central part of the disc.
a. During the operation.
b. After 16 days.
Defect not increased in size.

The condyle beneath it was hyperplastic, but its surface was not smooth : there was a cartilage bulge corresponding to the site of the defect in the disc.

c. In animals submitted to excision of the retrodiscal pad, the defect was found to have healed completely. The condyle retained its normal size : no hyperplasia.

Problem 3

— In only one of the 5 animals of group IV which were submitted to bilateral disc extirpation did bilateral hyperplasia (virtually symmetrical) occur. In the remaining 4, both condyles did become hyperplastic, but there was a distinct difference in size between left and right (Fig. VI.7). In this group, moreover, the articular surface of one of the condyles became irregular and somewhat nodular.

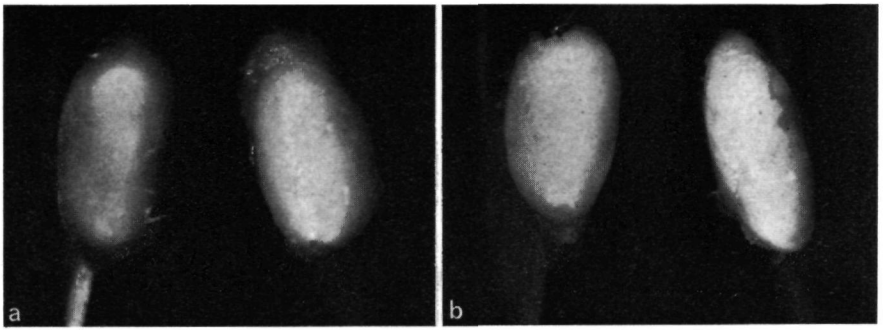


Figure VI.7. Bilateral extirpation of the disc.
a. The hyperplastic condyles are virtually symmetrical.
b. The hyperplastic condyles are not symmetrical.

Microscopic features of the hyperplastic condyles

— Sagittal as well as transverse sections of the hyperplastic condyles were histologically examined and compared with similar sections of the intact, contralateral, condyles.

— The histological features of the condylar caritlage and the underlying bone can be described as follows :

A. *Cartilage*

1. Overall picture:

a. The cartilage thickness in its totality showed an unmistakable increase. The cartilage was about evenly distributed over the condyle, whereas the control specimens showed diminution of the layer thickness from the caudal to the ventral aspect. This means that the ventral end of the hyperplastic condyle had most markedly increased (Fig. VI 8. a, b).

b. The number of cell layers determined at the thickest « caudal » site evidently exceeded that on the untreated side (Fig. VI 8. c, d).

c. In the case of hyperplasia, the cells were rounder at the level of the intermediate zone and smaller in the zone of hypertrophic cells, as compared with the intact side.

d. At the level of the proliferative and the intermediate zone, there was often an area of intercellular oedema parallel with the articular surface.

e. The division of cartilage cells into zones, although visible, was less well-defined than that on the intact side.

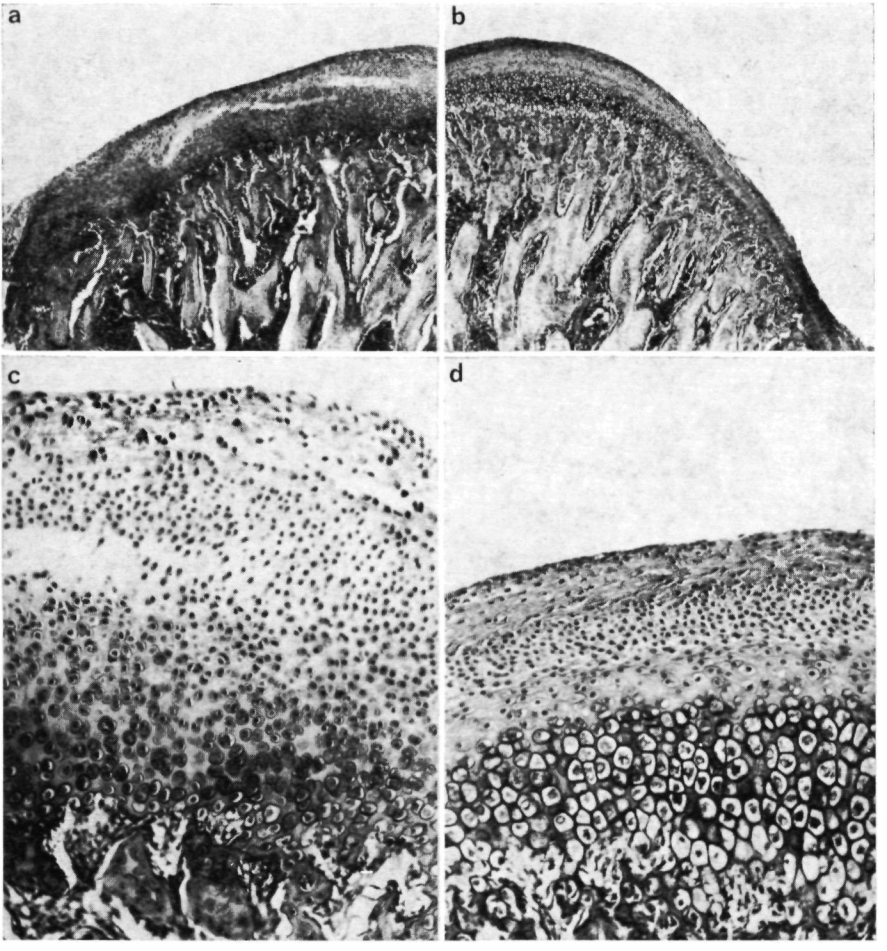


Figure VI.8. Microscopic features of the hyperplastic condyle (a, c) as compared with those on the intact side (b, d).
a and b, magnification 20x
c and d, magnification 100x

2. Cartilage zones:

a. The articular zone was virtually the same as that on the intact side. both in absolute thickness and in ratio between cells and intercellular substance. In some cases the cell distribution was irregular due to local areas of high cellularity.

b. The proliferative zone was hardly distinguishable from the intermediate zone. As already mentioned, the cells of both zones seemed to

be less flattened. Some occasional hypertrophic cells were visible in deeper parts of the intermediate zone.

c. The boundary between intermediate zone and zone of hypertrophic cells was likewise less well-defined. The cells of the latter zone were round but slightly smaller than those on the intact side.

B *Bone*

a. The primary spongy bone was formed in the normal manner on the treated side, and the number of osteoblasts was about the same as that on the untreated side.

b. The process of ossification took a normal course, with normal trabeculation.

C. *Articular disc*

The connective tissue in the disc remnants showed a variation in cellularity; there were local areas of low cellularity, associated with rough fibrous connective tissue showing partial hyaline degeneration.

DISCUSSION AND CONCLUSIONS

— The results of these experiments seem to provide an a answer to the first question posed in this chapter partial extirpation of the articular disc can lead to hyperplasia of the condyle of the mandible just as total extirpation can. It is a conspicuous fact that the degree of hyperplasia was about the same in both cases.

— This chapter also supplies an answer to the second question posed, which concerns the reactions of the articular disc and the condyle to partial disc excisions at different sites. Excisions of the retrodiscal pad were brought under the same heading.

— Defects in the articular disc showed no spontaneous healing. After excisions of retrodiscal tissue, however spontaneous healing did occur: adjacent tissue probably re-attached itself to the edge of the disc within a very short time, provided the edge itself was intact.

— The extent to which the amount of tissue excised together with the retrodiscal pad plays a role in the time required for restoration of the pad, and the extent to which this may be correlated with possible hyperplasia is not investigated.

— In most case it was found that after partial extirpation of the articular disc, the original defect increased in size. These findings confirm a report by Dubecq (1937), who also observed postoperative disc degeneration. The fact that Sprinz (1961) observed such disc degeneration only once is probably a coindence. The number of animals treated by him was too small to warrant definite conclusions.

— Another striking finding is that defects of the central part of the disc showed neither degenerative nor regenerative tendencies : they retained their original size. This fact has so far remained unexplained and, as far as could be establshed, no comparable experimental material is available. The vascularization pattern of the disc perhaps plays an important role in this respect, although (as described earlier), the nutrition of the more central portion of the disc does not seem tot be dependent on the vessels of the peripheral parts.

— Partial extirpation of the articular disc was followed within 16 days by evenly distributed hyperplasia of the mandibular condyle.

— Presumably, defects of the retrodiscal pad heal so rapidly that the condyle has no time to become hyperplastic.

— In the case of small defects of the central part of the disc, incipient local proliferation of cartilaginous components became visible at the condylar surface. The localization of this proliferation corresponded with that of the disc perforation. This proliferation is probably an initial stage of exostosis — a suspicion based on data obtained in further investigations, the results of which are not within the scope of this study.

— After bilateral disc extirpation, the hyperplasia was rarely found to be of the same size and shape on both sides. Since the influence of general factors was the same on both sides, the only remaining explanation is that the effect of a lesion of the articular disc is probably influenced by local factors. The possibility of anatomical variations is to be considered in this respect. Another possibility is that unilateral postoperative chewing influenced the effect of the disc extirpation. A final possibility is that marked differences in operative effect result from imperceptible differences in lesion « dosage ».

— In one of the condyles thus treated, an iregular and nodular articular surface was found in addition to hyperplasia. The most plausible explanation of this finding is that suggested by Sprinz (1954). He reported that in extirpation of the articular disc, a lesion was inflicted on the articular surface of the condyle itself, which caused the irregularity.

— The impression that a lesion of the condylar surface alone is not sufficient to account for this irregularity, is supported by the result of an experiment described by Hochman & Laskin (1965), who observed that defects of the condylar surface without disc extirpation healed completely after some time.

COURSE OF DEVELOPMENT OF HYPERPLASIA

INTRODUCTION

— It has been demonstrated in the preceding chapters that total or partial extirpation of the articular disc is followed after 16 days by hyperplasia of the underlying condyle.
— This chapter discuses the course of development of this hyperplasia during this 16-day period, with special reference to :
1. the time of onset of manifestations of hyperplasia;
2. the interval required for complete development of the hyperplasia;
3. the state of the hyperplastic condyle during the final days of the 16-day period.

— The extent to which cartilage and underlying bone are involved in hyperplastic development will also be considered.
— Finally the microscopic features of the process of degeneration of the articular disc will be discussed.

MATERIAL AND METHODS

— A total of 26 rats were used in this experiment. They were divided into six groups of 3 rats each, one test group of 4 rats and a control group of 4 rats.
— All animals were submitted to operation on the 56th day of life. The general conditions of this experiment (accommodation and care, and the sex of the animals) were the same as those described in preceding chapters. The animals wre sacrificed after the following intervals :

Group	*Days after operation*	*Number of animals*
test group I	2	3
test group II	4	3
test group III	6	3
test group IV	8	4
test group V	10	3
test group VI	12	3
test group VII	14	3
control group	8	4

— Th mandibles were excised immediately after sacrifice and kept in 4 % neutral formalin solution.

— The condyles were photographed in the cranial view as described in chapter V. Next, the mandibles were divided at the symphysis and radiographs were made of the halves in the standardied manner described.

— For microscopic examination, sagittal as well as transverse sections were cut and stained with haematoxylin-eosin as well as Van Gieson stains.

— The hyperplasia was macioscopically assessed on the basis of the photogaphs. Assessment of the hyperplasia of the osseous part of the condyle was based on the radiographs. (Soft-tissue features were left unconsidered).

— Whenever estimates were made from the radiographs, this was done by comparison of superimposed tracings of the two mandibular halves, enlarged by factor 10. In view of the fact that there was no possibility of using exact measuring-points, this type of estimate was accepted as the approach of choice (Fig. VII.1).

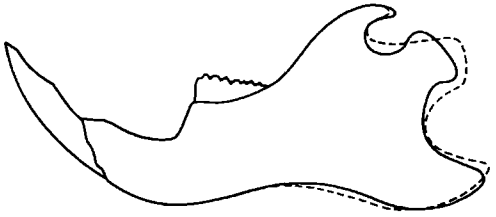


Figure VII 1. Superimposed tracings of the two halves of the mandible Continuous line indicates test side Dotted line indicates control side

— The microscopic features of cartilage as well as of bone will be described per test group.

RESULTS

— In evaluating results obtained per test group, the following should be borne in mind.

— There are individual differences withing the groups. Nevertheless it can be maintained that manifestations per group were sufficiently similar to justify conclusions per group. The results obtained after the various intervals listed above will be discussed in succession.

Test group I (2 days after operation)

Photographs

— The cranial photographs of the condyles revealed no demonstrable difference between right and left condyles (Fig. VII.2a).

Radiographs

— The radiological features were similarly about the same on both sides : the course of the trabeculae, bone density and curvature of the articular contour of the condyle appeared to be the same (Fig. VII.3a).

Microscopic features

— Treated and untreated specimens did not differ in total thickness of cartilage, zonal distribution and normal course of the process of ossification.

Test group II (4 days after operation)

Phoographs

— Treated specimens showed no visible hyperplasia as compared with untreated specimens (Fig. VII.2b).

Radiographs

— No visible difference between left and right condyles (Fig. VII.3b).

Microscopic features

— Signs of hyperplasia of the cartilaginous lining were visible. These signs were most pronounced on the ventral side of the condyle. A strikking feature was a slight increase in the number of cellular layers on the treated side as compared with the untreated side. The different layers were clearly distinguishable. Flattened cells were rounder at the level of the proliferative and the intermediate zone. A somewhat spherical cell shape as compared with the intact side (Fig. VV.4a).

Test group III (6 days after operation)

Photographs

— There was unmistakable hyperplasia of the left condyle in this group,

the difference from the right condyle being quite marked. The hyperplasia of the left condyle was most pronounced in the transverse direction, the condyle having lost its pear shape and assumed an oval shape tending to become spherical. The surrounding disc remnants were still clearly visible (Fig. VII.2c).

Radiographs

— The radiographs showed no significant difference between left and right condyles; both showing what seemed tot be the same trabecular structure. The curvature of the articular contour of the left condyle was of normal shape (Fig. VII.3c).

Microscopic features

— The cartilage of the left condyle showed unmistakable hyperplasia in this group, its total thickness having increased. The hyperplasia involved all zones except the articular zone, which had remained unchanged.

— The greatest increase in cartilage thickness was observed in the ventral part. Consequently the total cartilage thickness hardly showed the dorsoventral decrease observed on the intact side. The increase in cartilage thickness was due to an increased number of cells rather than to accumulation of fluid.

— The *articular zone* was of unchanged thickness and ratio between cells and intercellular substance. The cells of the *proliferative* and particularly of the *intermediate zone* had become unmistakable rounder. The intermediate zone, moreover, proved to contain some cells more closely resembling cells of the hypertropic zone.

— Endochondral ossification was normal. The trabecular pattern of the spongy bone was the same on both sides (Fig. VII.4b).

— The more central parts of the disc, adjacent to the defect, showed necrosis (Fig. VII.5).

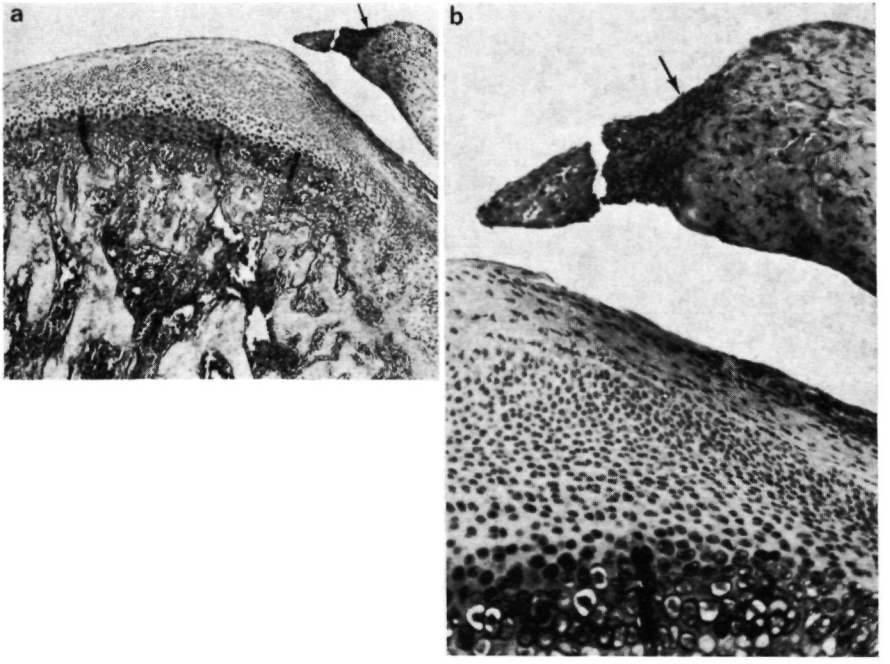


Figure VII.5. Sagittal section through dorsal part of condyle and remainder of disc. Line of demarcation indicated by arrow.
a. enlarged 20x.
b. enlarged 100x.

Test group IV (8 days after operation)

Photographs

— The specimens obtained 8 days after operation showed little change as compared with those obtained 6 days after operation. The sagittal axis had incerased in length, but the length of the transverse axis had remained unchanged (Fig. VII.2d).

Radiographs

— Although there were individual differences, as pointed out, the osseous part of the condyle was longer in sagittal direction on the treated than on the intact side. The course of the trabeculae was radiologically normal, as was the curvature of the articular contour of the left condyle (Fig. VII.3d).

Microscopic features

— The total cartilage thickness seemed hardly different from that in test group III. It was unmistakably hyperplastic as compared with that on the intact side. In the area of transition between the proliferative and the intermediate zone there were occasional relatively small crevices halfway along the sagittal axis, with some oedema.
— The cells of the layer of hypertrophic cells were slightly smaller on the left than on the intact side. The process of ossification at the boundary between cartilage and bone was normal in this group also. Trabeculation at a slightly deeper level was normal (Fig. VII.4c). The necrotic part of the disc had disappeared, the remainder of the disc showing the hyaline degeneration described in the previous chapter.

Test group V (10 days after operation)

Photographs

— The photographs showed virtually no further change of the hyperplastic condyles as compared with group IV (Fig. VII.2e).

Radiographs

— In sagittal direction the osseous part of the left condyle was larger than that of the right. The diameter in question also seemed somewhat larger than the corresponding dimension of the left condyle in test group IV. As in the latter group, the density of the bone of the left condyle was increased (Fig. VII.3e).

Microscopic features

— The total cartilage thickness had remained unchanged as compared with that in group IV. The zonal division, which was totally lost in the latter group, seemed to return to some extent in this group, although only three zones were distinguishable: articular zone, a layer encompassing proliferative and intermediate zone, and a layer at the level of the zone of hypertrophic cells. Ossification was normal (Fig. VII.4d).

Test group VI (12 days after operation)

Photographs

— No difference was demonstrable from the photographs of group V (Fig. VII.2f).

Radiographs

— The difference in sagittal diameter between the osseous part of the left and that of the right condyle had increased. As in the preceding groups, there was some difference in bone density between the left and right condyle (Fig. VII.3f).

Microscopic features

— The overall cartilage features were virtually the same as those in group V. But the above-mentioned space at the level of the proliferative/intermediate zone was more pronounced. The impression was that the division into cartilage zones was more distinct again. The cells of the articular zone seemed to tend to form groups. The cells of the zone of hypertrophic cells were even smaller in comparison with those on the intact side than in test groups IV and V.

Test group VII (14 days after operation)

Photographs

— The features of the condyles had remained unchanged.

Radiographs

— The length of the sagittal axis of the osseous part of the condyle as well as the bone density of condyle and neck of the mandible had remained virtually the same as in the preceding group.

Microscopic features

— The total cartilage thickness had remained unchanged, the zones being more clearly demarcated than in the preceding group. With some difficulty, four different zones could again be distinguished. The tendency of the cells of the articular zone to form groups was more pronounced. The cells of the zone of hypertrophic cells were still smaller than those in the corresponding contralateral zone.

DISCUSSION AND CONCLUSIONS

— In the study of hyperplasia of the condyle of the mandible described in chapter V, the experimental period was arbitrarily set at 16 days. It is demonstrated in this chapter that the climax of the hyperplastic process falls within this 16-day period.

Maximal cartilage activity was found between the 4th and the 8th postoperative day; the hyperplastic changes increased until about the 8th postoperative day and then were stabilized, as far as cartilage was concerned, until the 12th day. After the 12th day there was gradual diminution of some of the characteristic features of hyperplasia, and this was found to continue beyond the 16-day limit in all cases.

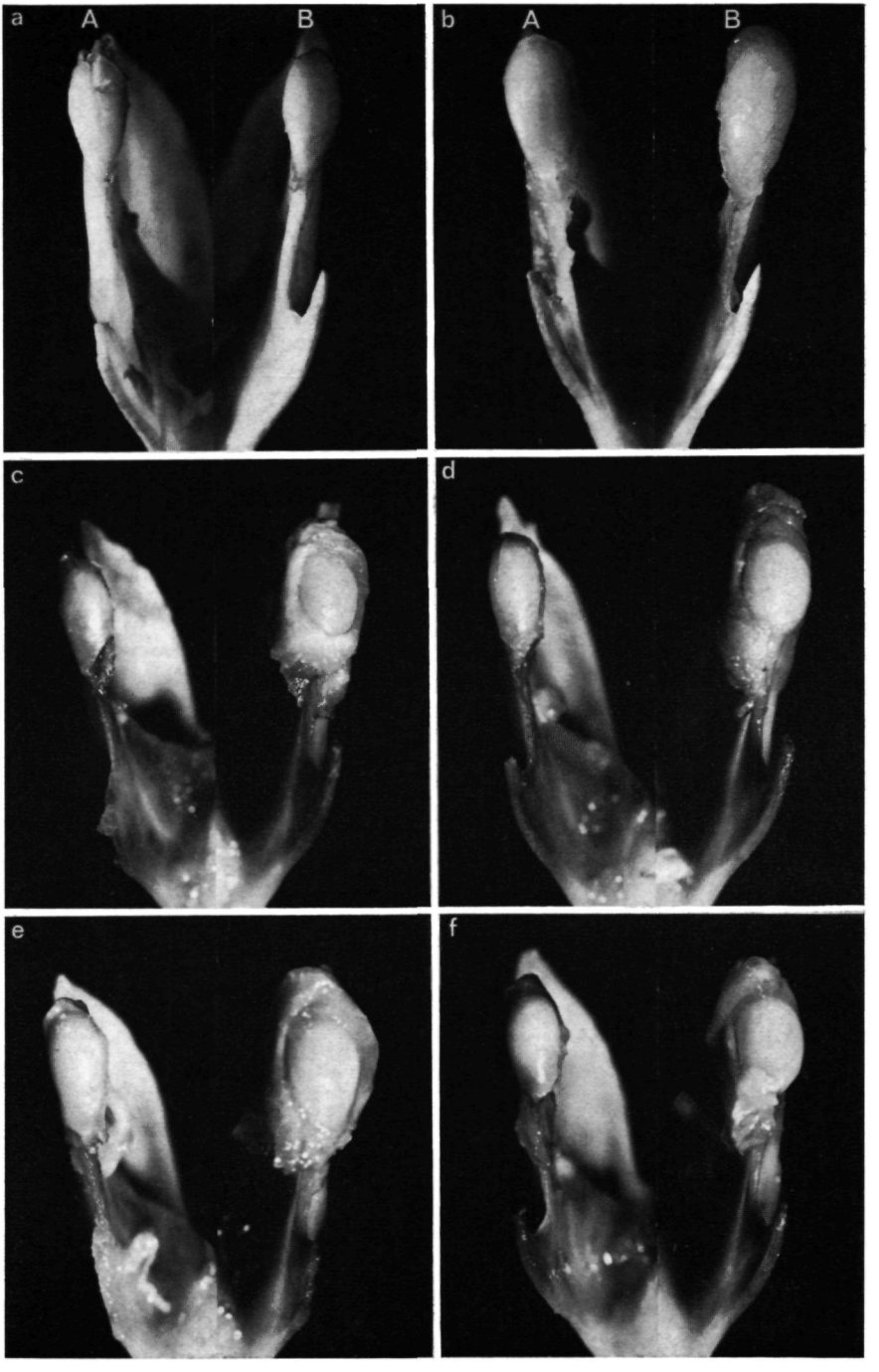
— The above conclusion is in agreement with that of Bisgard (1936), in whose experimens the growth of limbs in young goats was stimulated. This author reported that initially there was acceleration of the growth process of the traumatized limb as compared with the intact limb. Subsequently the growth rate of the test limb gradually diminished. An indication of a similar effect can be observed in our experiments on the mandibular condyle.

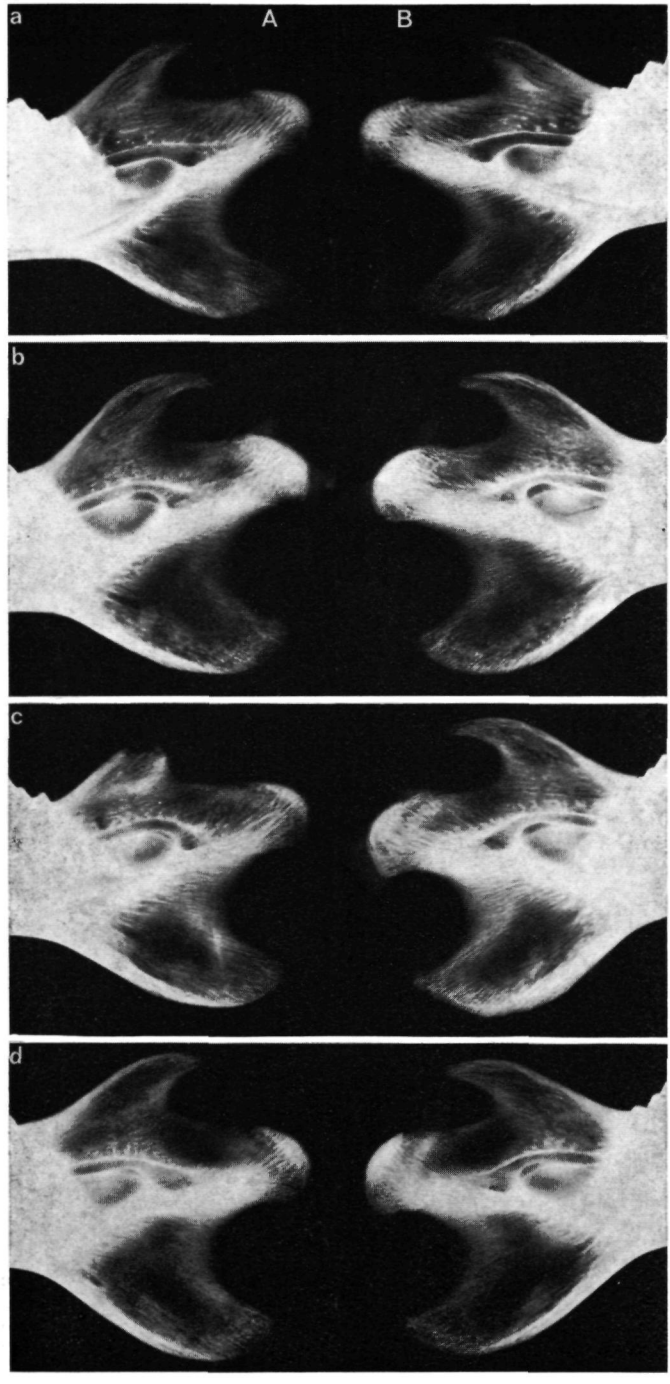
— During the initial phases, the hyperplasia developed fairly rapidly. The cartilage initially showed rather abrupt hyperplasia, and in the bone this process followed more gradually. The articular zone of the cartilage initially remained unchanged, while the underlying zones became more active. The demarcrations between the zones faded and were ultimateley effaced. In later stages, the dimensions of the cells of the zone of hypertrophic cells slightly diminished. Ossification took place without these cells having attained full development.

— The hyperplasia was most marked on the ventral side of the condylar cartilage. It is difficult to explain this. Extirpation of the articular disc promoted the devlopment of condylar hyperplasia, the latter being most pronounced at the site of least counterpressure of the condyle the articular fossa on : this is on the ventral side owing to the position of the condyle in the fossa.

— With regard to the remnants of the articular disc, it was histologically demonstrated that the most central parts became necrotic and were sequestrated within 8 days.

Figure VII.2. Cranial aspect of condyles. A = control side. B = test side.
a. two days after operation.
b. four days after operation.
c. six days after operation.
d. eight days after operation.
e. ten days after operation.
f. twelve days after operation. Magnification 4,5x


a
A
B
b
A
B
c
d
e
f


a
A
B
b
c
d

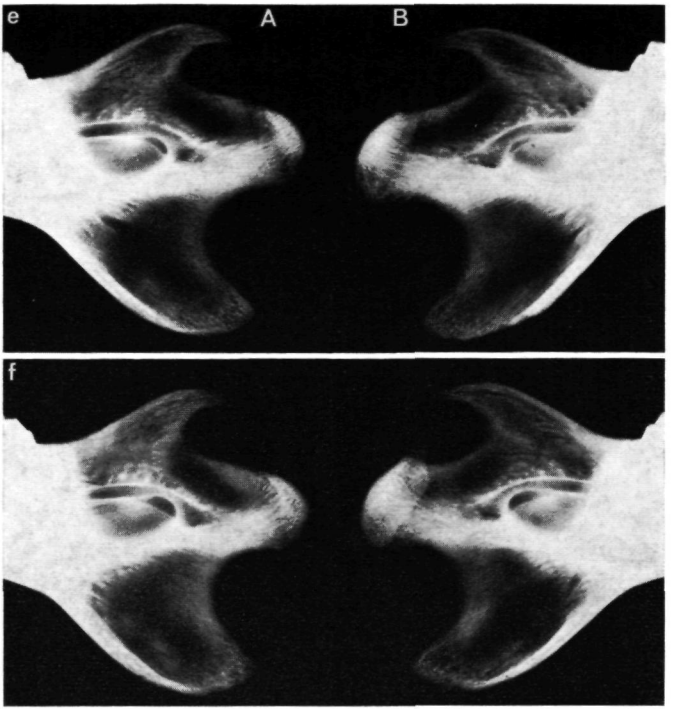
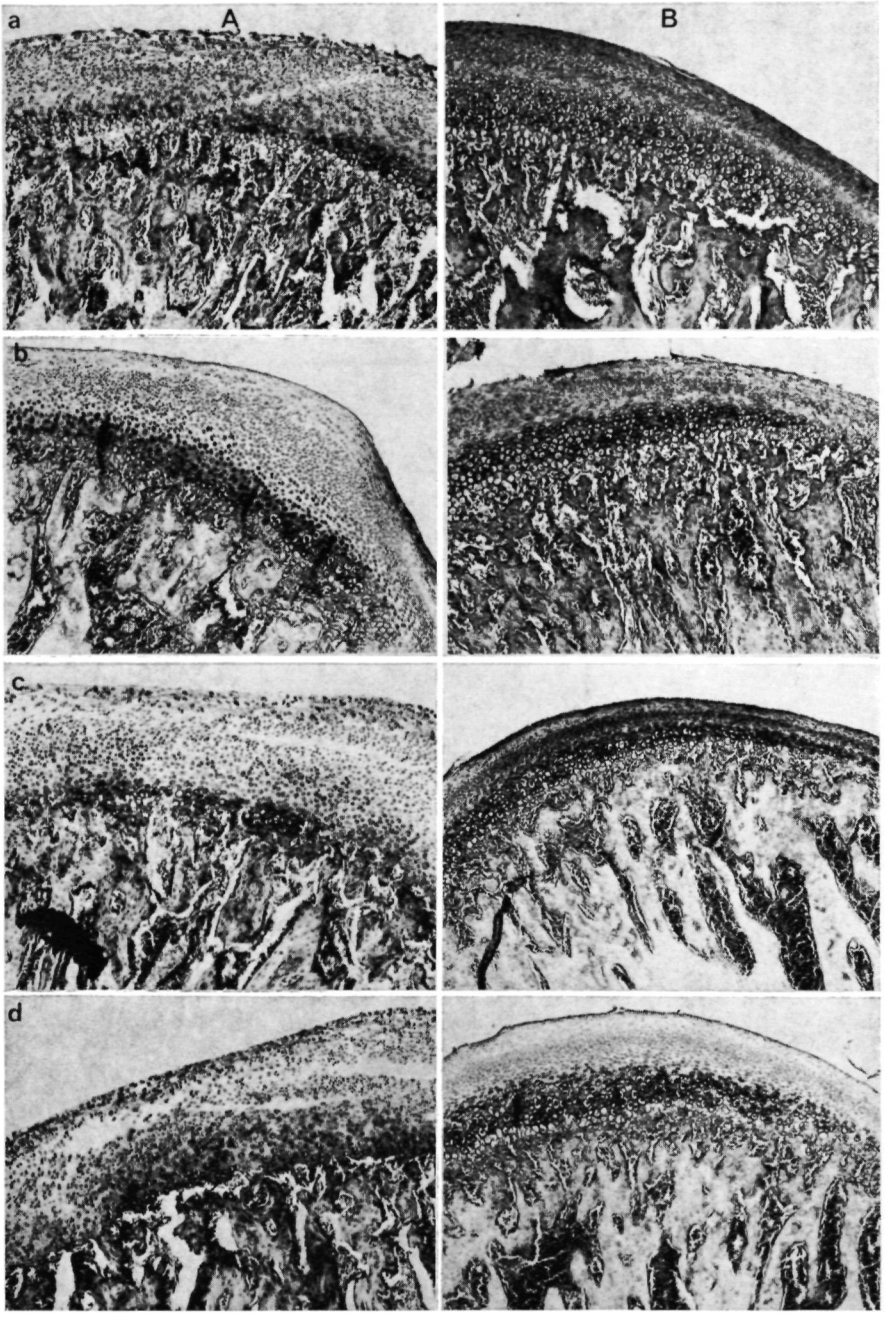


Figure VII.3. Lateral radiographs of ascending ramus.
A = control side. B= test side.
a. two days after operation.
b. four days after operation.
c. six days after operation.
d. eight days after operation.
e. ten days after operation.
f. twelve days after operation. Magnification 6x

Figure VII.4. Sagittal sections through both condyles.
Magnification ± 40x. A = test side. B = control side.
a. four days after operation.
b. six days after operation.
c. eight days after operation.
d. ten days after operation.


A
B
a
b
c
d

CHAPTER VIII

RESULTS OF OPERATIONS AT DIFFERENT AGES

INTRODUCTION

— The starting-point of the experiments so far described was the assumption that « a traumatic lesion at the end of the growth period can give rise to hyperplasia of the mandibular condyle ». The time at which the lesion was inflicted on the test animals was adjusted accordingly.

— This chapter will discuss the extent to which this view is justifiable if « traumatic lesion » equates to excision of a relatively large part of the articular disc.

MATERIAL AND METHODS

— For this purpose we used 25 male rats of different ages, both younger and older than the animals so far described. The operations were performed at ages of 32, 40 and 48 days in the younger categories, on adult rats aged 5 months, and on very old rats, aged 22 months. More than one-half of the articular disc was thus excised in the following five test groups of 5 rats each.

Group	*Age*	*Number of animals*
I	32 days	5
II	40 days	5
III	48 days	5
IV	5 months	5
V	22 months	5

— Accommodation and postoperative care were again as described in previous chapters. The animals were sacrificed 16 days after the operation. The mandibles were disseced-out immediately and kept in the conventional 4 % neutral formalin solution. The condyles were always photographed in the cranial view, whereupon the mandibles were divided at the symphysis and radiographs were obtained with the aid of the séino-

graph as described earlier. Some mandibles in each group were processed for hisological examination.

— As in the preceding chapter, the interpretations were based on photographs, radiographs and histological findings.

RESULTS

Group I (age 32 days)

Photographs

— These showed the familiar features of hyperplasia, the left condyle being unmistakaly larger than the right (Fig. VIII.1a).

Radiographs

— These showed that the osseous part of the left condyle had increased in sagittal direction. This condyle seemed to have become more radiopaque. The cranial end of the left condyle was flattened, unlike that of the right.

— On the ventral side of the condyle, a « prominence » was often visible. The neck of the mandible seemed to be more radiopaque. There was no marked difference between left and right in the direction of the trabeculae. The length of the condylar process of the mandible seemed less on the left than on the right (Fig. VIII.2a). This estimate again was based on comparison of superimposed tracings of the two mandibular halves, enlarged by factor 10. (Fig. VII.1)

Microscopic features

— The cartilage of the left condyle was definitely hyperplastic as compared with that of the right. The familiar pattern of cartilage hyperplasia (described in 56-day-old rats in chapter VI was identifiable. Cartilage thickness was greatest on the ventral part of the condyle. The four carilage zones were hardly disinguishable.

— The cells of the articular zone tended to form groups. The previously described « space » at the level of the proliferative/intermediate zone was visible in this test group also. The cells of the zone of hypertrophic cells were smaller than those of the corresponding zone on the intact side. Ossification was normal, osteoblast activity being the same as that on the intact side.

Group II (age 40 days)

— Photographs, radiographs and microscopic findings revealed the familiar features of hyperplasia of the left condyle, as in the preceding group.

Group III (age 48 days)

— This group resembled the earlier described 56-day-old rats more closely than the abovementioned age groups.

Photographs

— The familiar features of hyperplasia of the left condyle were visible (Fig. VIII.1b).

Radiographs

— The osseous part of the left condyle had increased but the length of the entire condylar process was only slightly shorter than on the intact side (Fig. VIII.2b).

Microscopic features

— The familiar pattern of hyperplasia of the left condyle was identifiable.

Group IV (age 5 months)

Photographs

— The familiar features of hyperplasia of the left condyle were visible. However, the hyperplasia seemed less pronounced than that in the abovementioned age groups (Fig. VIII.1c).

Radiographs

— The sagittal dimension of the left condyle seemed hardly larger, if at all, than that of the right. There was some evidence of a trabecular pattern in the left condyle, but less pronounced than in the abovementioned age groups. The curvature of the articular contour of the condyle was the same on both sides. Nor did left and right differ in the length of the condylar process (Fig. VIII.2c).

Microscopic features

— The cartilage of the left condyle was hyperplastic, as in the above-

mentioned age groups. The zones were less distinguishable than in the younger animals. Ossification was regular, but the « front of ossification » was less broad than in the jounger animals.
— Osteoblasic activity was less marked than in the previous groups. The osseous part of the condyle was more comptact, and the visible bone trabeculae were thicker than those in the younger age groups. On the whole, however, the pattern on the left was the same as that on the right side.

Group V (age 22 months)

Photographs

— These were largely the same as those in group IV (Fig. VIII.1d).

Radiographs

— These were hardly different from those in group IV, but a striking feature was that the entire condylar process consisted of compact bone, on the left as wel as on the right. Even on the intact side there was a hint of a small prominence on the ventral side.

Microscopic features

— On the intact side the cartilage lining was exceedingly thin, and consisted of an articular and a proliferative zone The thickness of the lining encompassed only a few layers of cells Hypertrophic cartilage cells were virtually absent.
— Immediately beneath the cartilage, compact bone was visible nearly everywhere. The remainder of the condylar process consisted almost entirely of compact bone. A few osteoblasts were identifiable with difficulty at the boundary between cartilage and bone. The osteoblasts were flattened : so-called « resting » osteoblasts (Fig. VIII.3B en Ba).
— On the left, however, there was unmistakable hyperplasia of the entire cartilage lining. All the zones were identifiable, including the zone of hpertrophic cells, which consisted of several cell layers. The cartilage was thickest towards the ventral and dorsal part of the condyle of the mandible, and thinnest in the central part.
— The articular zone was of unchanged thickness. The proliferative and intermediate zones were clearly thicker than those on the intact side. But the most conspicuous fature was the zone of hypertrophic cells, which on the test side consisted of several cell layers The cleraly hypertrophic

cells were largely of similar appearance and size as the cells of the hypertrophic zone in much younger animals (Fig. VIII.3A, Aa, Ab).

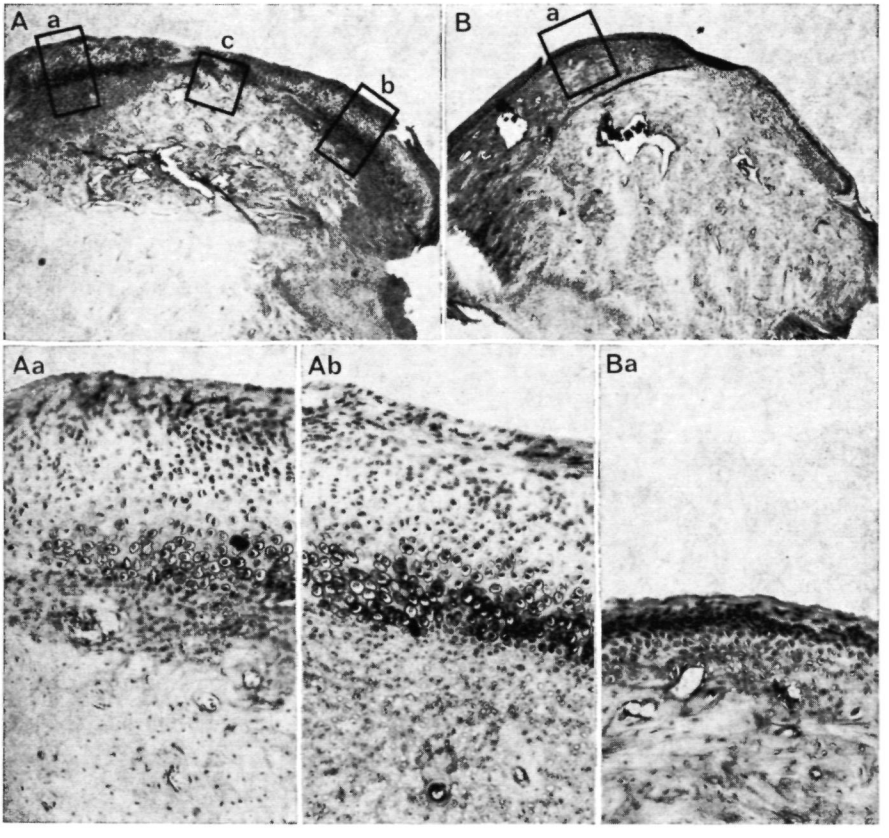
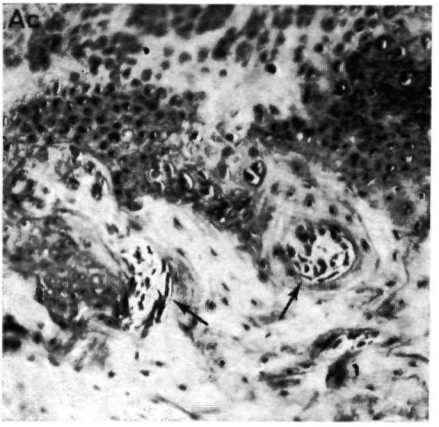


Figure VIII.3. Sagittal sections through condyles of the retaged 22 months at the time of the operation. A = test side. B = control side.
Magnification 20x
Aa. Detail of ventral aspect of test condyle. Magnification 80x
Ab. Detail of dorsal aspect of test condyle. Magnification 80x
Ba. Detail of control condyle. Magnification 80x

— The almost continuous plate of bone beneath the cartilage showed occasional interruptions, at which sites trabeculae had appeared beneath the cartilage. At these sites endochondral ossification, although somewhat irregular, was unmistakable.

— Osteoblasts were identifiable without difficulty. These were of cubinal shape : so-called « active osteoblasts » (Fig. VIII.3Ac).



Ac. Detail of central part of test condyle. Magnification 140x
Arrows indicate the sites where cuboidal osteoblasts are visible.

DISCUSSION AND CONCLUSIONS

— The experiments described in this chapter demonstrate that extirpation of the articular disc causes hyperplasia of the mandibular condyle (at least of its cartilage), regardless of age. Whether the underlying bone will develop macroscopic evidence of hyperplasia seems to depend on the subject's age.
— In the case of very young animals (group I and II), although the osseous condyle as such was hyperplastic, the length of the condylar process on the test side seemed less than that on the intact side.
— In the case of young animals (group III, and the 56-day-old animals used in previous experiments), enlargement of the condylar process on the test side seemed more marked than in the younger test groups. The dimensions of the osseous part of the condyle also seemed to exceed those on the intact side. Moreover, the length of the condylar process was roughly the same as on the intact side, and in a few animals in fact slightly larger.
— Histological differences between the animals of the abovementioned groups were small, on the test side as well as on the intact side. For example, the condyle in the 32-day-old animals and that in the 56-day-old

animals showed no marked histological differences either in cartilage or in bone.

— It therefore seems as if the exact descriptions of histological differences between animals of not very different age in the literature, should be regarded with some scepticism. The animals which underwent the operation at the age of 5 months (group IV) responded in accordance with the pattern described The cartilage on thet est side was hyperplastic. The bone of the condylar process in its totality was more compact than that in the younger age groups. Ossification was normal on both sides. On both sides, fewer trabeculae were visible, and fewer osteoblasts were found

— Radiologically, there was no significant difference between left and right in the dimensions of the condylar process.

— In the very old rats (group V, aged 22 months), there was no radiologically demonstrable difference between left and right in the dimensions of the osseous part of the condyle. The only difference from the younger group was that the trabecular pattern had become indistinguishable.

— Histologically, however, this very old group was of great interest. The cartilage lining the condyle on the intact side was consistent with the picture described in the literature, the various zones being either very thin or entirely absent. True hypertrophic cartilage cells were hardly found.

— This senile aspect of the cartilage disappeared on the test side, and a relatively thick zone of hypertrophic cells of virtually normal size reappeared. Beneath this cartilage layer the bone plate on the test side was discontinuous at several sites.

— Although irregular, endochondral ossification was again evident A small number of new trabeculae could be seen at the boundary between cartilage and bone.

— The osteoblasts were of the « resting » type on the intact side, but on the test side had increased in number and were of the cubical type : so-called « active » osteoblasts.

— These findings correspond to some extent with the phenomena described by Collins *et al.* (1946) in the condyle of the aged rat after administration of growth hormone.

— They confirm the view that the mandibular condyle retains its capacity to grow even at a very advanced age. Besides growth hormone, extirpation of the articular disc can re-activate the growth of the condyle of the mandible in the rat, as this study has demonstrated.

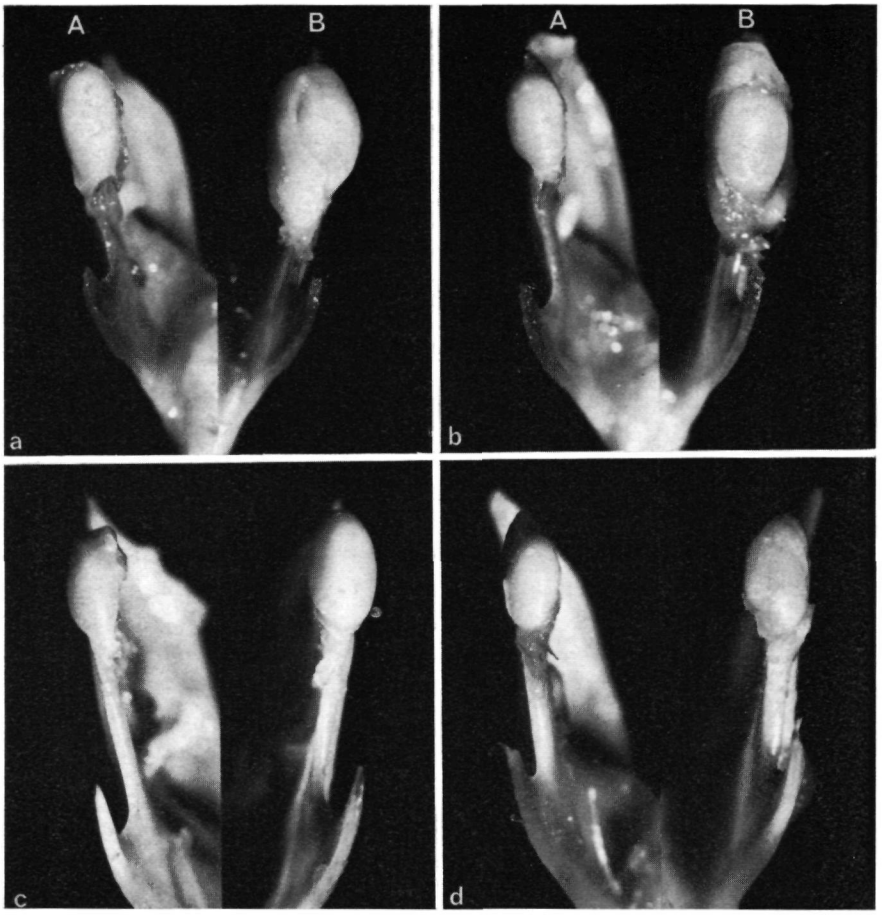
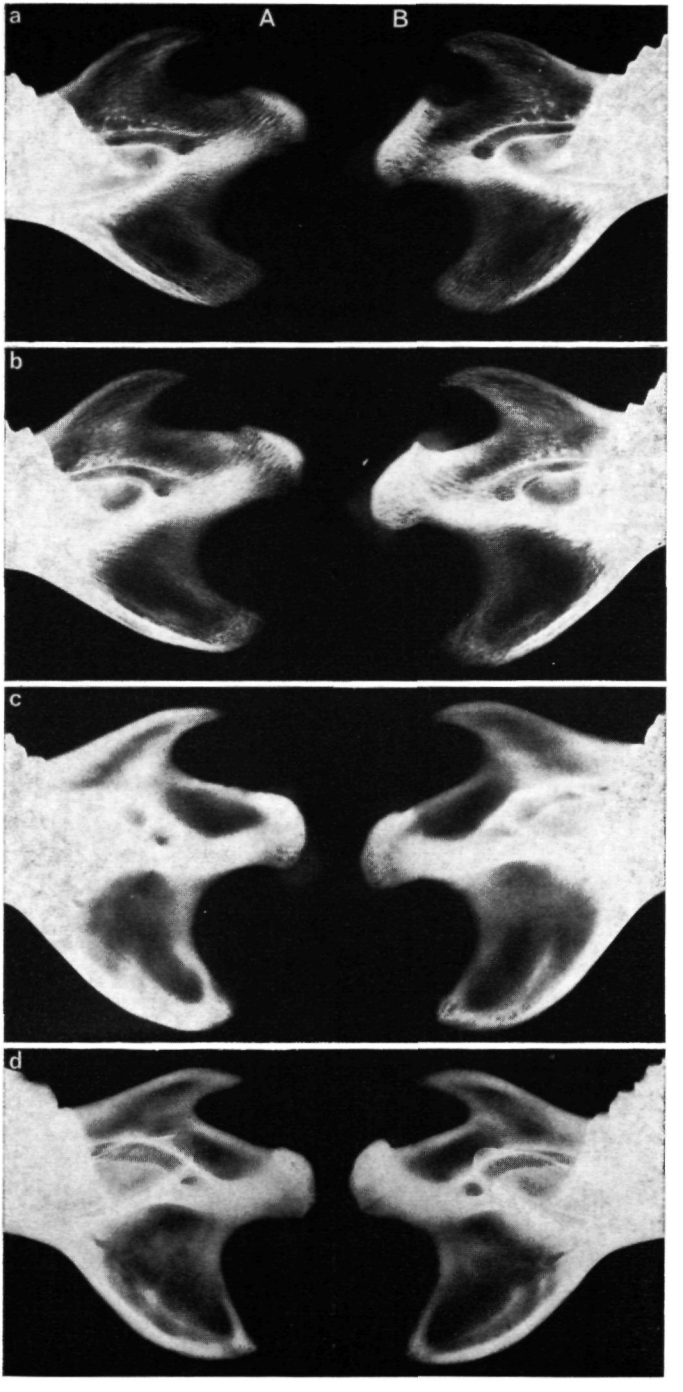


Figure VIII.1. Cranial aspect of condyles 16 days after operation.
A = control side. B = test side.
a. animals aged 32 days at time of operation.
b. animals aged 48 days at time of operation.
c. animals aged 5 months at time of operation.
d. animals aged 22 months at time of operation. Magnification 4,5x

Figure VIII.2. Lateral radiographs of ascending ramus.
A = control side. B = test side.
a. animals aged 32 days at time of operation.
b. animals aged 48 days at time of operation.
c. animals aged 5 months at time of operation.
d. animals aged 22 months at time of operation. Magnifcation 6x


a
A
B
b
c
d

SUMMARY

— The introduction to this thesis outlines the considerations which have prompted the experimental study described. The principal consideration was that the aetiology of unilateral hyperplasia of the condyle mandible is the subject of speculations which can differ from one author to another. These aetiological factors, and other questions, were investigated in an animal-experimental approach not previously used.

— In this study an attempt was made to achieve stimulation of the endochrondral growth of the mandibular condyle by experimental means. This stimulation was effected by means of a defined traumatic lesion inflicted on the temporomandibular joint of the test animals. The secondary purpose of the experiments was to study some additonal factors considered to be of importance for a better understanding of this abnormality.

— Chapter I present a survey of the literature which is sufficiently comprehensive to give an impression of the knowledge required as a basis for this study. It warrants the conclusion that unilateral hyperplasia of the mandibular condyle is an acquired abnormality. Patients suffering from this abnormality are otherwise quite healthy.

— The literature indicates that a condyle is generally regarded as hyperplastic if it is « distinctly larger » than the condyle considered to be intact. There proved to be no specific macroscopic or microscopic criteria which establish a diagnosis of unilateral condylar hyperplasia.

— It is apparent from the various suggestions made in the literature about the cause of unilateral hyperplasia of the mandibular condyle, that a traumatic lesion of the temporomandibular joint, usually at an early age, is the causal factor most frequently mentioned. This is further discussed, and the concept « traumatic lesion » in this context is more clearly defined.

— Chapter II outlines a number of operative techniques on the basis of data in the literature on stimulation of endochondral growth in general, and that of the mandibular condyle in particular. The purpose of these techniques is to promote stimulation of the growth of the condyle and they are discussed in chapter V.

— Chapter III is devoted to a discussion of the animals used and the relevant experimental conditions. It also discusses the operative technique commonly used in these experiments in general terms, and the methods used in analysing results.

— Chapter IV discusses the principal data from the literature on the anatomy, microscopic features and growth of the temporomandibular joint of the rat. The description confines itself to what is important for the operative procedures and for comparison of normal with hyperplastic condyles.

— Chapter V elaborates on the concept « traumatic lesion ». It describes how six test groups were formed, in each of which a different type of defined traumatic lesion was inflicted on the temporomandibular joint. For comparison, four control groups were used.

— Of the various operative techniques used, that in which the traumatic lesion consisted of extirpation of the articular disc proved to produce a statisticaly significant hyperplasia of the condyle. This hyperplasia was manifested by an increased length of the sagittal and the transverse axis of the articular surface of the condyle involved, and by an increased ramus height.

— The transverse axis of the articular surface of the condyle showed the greatest increase in length, followed by the sagittal axis and finally by the ramus height (which was only moderately increased). The increase must be ascribed to extirpation of the articular disc as such. In addition, indications were found of increased ramus height after intervention with the venous flow of the condyle. Its not excluded that a combination of partial damage to the arterial blood supply and damage tot he venous flow might lead to hypoplasia of the mandibular condyle.

— In this experimental study, extirpation of the articular disc was selected as the operative technique of choice for the purpose of these experiments.

— Chapter VI discusses the following questions as a subject of experimental study :

a. can partial extirpation of the articular disc lead to hyperplasia of the condyle? The results are compared with those obtained after total extirpation of the articular disc;
b. how does the articular disc behave after excision of part of this disc? Defects of varying size were produced in the disc, and regenerative capacities were studied;
c. is bilateral extirpation of the articular disc followed by comparable, uniform bilateral hyperplasia?

— Next, this chapter discusses the histological features of the hyperplastic condyle. The experiments showed that partial extirpation of the articular disc is just as capable of leading to hyperplasia of the mandibular condyle as total extirpation.

— There was no regeneration of the various defects produced in the articular disc of the mandible. Defects of the so-called retrodiscal pad, however, regenerated within a relatively short time. Defects of the periphery of the articular disc were followed by further degeneration of the disc towards its centre. This degeneration was to some extent dependent on the dimensions of the initially excised part of the articular disc.

— In all these cases, evenly distributed hyperplasia of the underlying condyle occurred.

— Small central defects of the articular disc remained unchanged until the end of the experiment. Again, the underlying condyle was hyperplastic. The articular surface opposite the defect in the disc tended to show local proliferation in the direction of the defect. This proliferation was most manifest in the case of very small defects of the central part of the disc.

— Regarding question c., it was found that bilateral disc extirpartion was seldom followed by comparable uniform hyperplasia of both condyles. This may have been due to local factors influencing the effect of extirpation of the disc.

— The most striking microscopic feature was the increased cartilage thickness on the test side. All cartilage layers had increased in thickness except the articular zone, which in this respect had remained unchanged. The cells of the proliferative and the intermediate zone were rounder than those on the intact side. The cells in the zone of hypertrophic cells were somewhat smaller on the test side than ont he intact side.

— In all cases the endochondral ossification took its normal course.

— Chapter VII considers the course of development of hyperplasia following partial or total disc extirpation. It was found that the development of hyperplasia was initially observed in the cartilage, which rather abruptly attained a certain thickness and then remained constant. This applied to all layers of cartilage except the articular zone. Regression of the process of cartilage hyperplasia was observed in later stages.

— The bone followed this development in a more gradual fashion; again, stabilization of the hyperplastic process occurred in later stages.

— Chapter VIII examines the possible importance of the age at which the aricular disc is extirpated for the develpoment of hyperplasia of the mandibular condyle.

— It was found that the hyperplastic process of the cartilage was independent of the age of the test animals at the time of operation.

In the bone, the hyperplastic process, or at least its macroscopic features, seemed to be dependent on age. In the groups of very young animals, shortening of the articular process was observed after 16 days, while the condyle itself was hyperplastic.

— The condyle was also hyperplastic in the group of young animals, in which the length of the condylar process seemed greater on the test side.

— In older animals there was no macroscopic difference between the test side and the intact side in the osseous part.

— Histologically, the very young, the young and the adult animals showed no difference between the test side and the intact side other than marked hyperplasia of the cartilage. In senile animals, there was evidence of « rejuvenation » of the cartilage on the test side.

— The articular zone remained unchanged, but the proliferative and intermediate zones showed an unmistakable increase in thickness. The most conspicuous finding, however, was the reappearance of a zone of hypertrophic cells on the test side. The thickness of this zone encompassed several cell layers. In size and appearance, the cells of this zone resembled the cells from the same zone in much younger animals. Moreover, a retrun of endochondral ossification was observed.

SAMENVATTING

In de inleiding van deze dissertatie zijn de overwegingen aangegeven, die aanleiding zijn geweest tot het verrichten van een experimenteel onderzoek. De voornaamste van deze overwegingen is, dat betreffende de aetiologie van de eenzijdige hyperplasie van het caput mandibulae slechts gissingen bestaan, die van auteur tot auteur kunnen verschillen. Door middel van een nog niet eerder toegepaste dier-experimentele benadering zijn enkele aetiologische factoren nader onderzocht.
In dit onderzoek is getracht langs experimentele weg een stimulatie van de endochondrale groei van de condylus mandibulae tot stand te brengen. Deze stimulatie is verkregen door middel van een gedefinieerd trauma op het kaakgewricht van de experimentele dieren. In tweede instantie zijn enkele factoren, die verder van belang worden geacht voor een beter begrip van de afwijking, nader bestudeerd.
In hoofdstuk I wordt een zodanig uitgebreid literatuuroverzicht gegeven, dat men een juiste indruk kan hebben van die benodigde kennis die als basis heeft gefungeerd voor dit onderzoek. Men kan hieruit de conclusie trekken dat de eenzijdige hyperplasie van het caput mandibulae tot de verworven afwijkingen behoort. Patienten met deze afwijking zijn overigens geheel gezond.
Uit de literatuur blijkt dat over het algemeen een condylus als hyperplastisch wordt beschouwd als deze « duidelijk groter » is vergeleken met de als intact beschouwde condylus. Verder blijkt het dat er geen specifieke macroscopische of microscopische criteria zijn die tot de uitspraak, eenzijdige condylus hyperplasie, leiden.
Uit de verschillende suggesties, die in de literatuur worden gevonden voor de oorzaak van de eenzijdige hyperplasie van het caput mandibulae, blijkt, dat een trauma op het kaakgewricht, meestal op jeugdige leeftijd, het meest frequent als causale factor vermeld wordt. Hierop wordt verder ingegaan waarbij tevens het begrip « trauma » voor dit doel nader wordt omschreven.
In Hoofdstuk II zijn op basis van gegevens uit de literatuur betreffende stimulatie van de endochondrale groei in het algemeen en die van het caput mandibulae in het bijzonder, zijn een aantal operatieve technieken beschreven. Ze hebben ten doel de stimulatie van de groei van het caput mandibulae te bevorderen en vormen het onderwerp van hoofdstuk V.

Hoofdstuk III is gewijd aan de bespreking van de gebruikte dieren en van de relevante experimentele omstandigheden.
Het gemeenschappelijke deel van de operatietechnieken wordt hier in het algemeen besproken evenals de wijze waarop de resultaten worden gecontroleerd.

In hoofdstuk IV zijn de belangrijkste gegevens uit de literatuur weergegeven betreffende de anatomie, het microscopische beeld en de groei van het kaakgewricht van de rat.

De beschrijving is beperkt tot datgene wat van belang is voor het uitvoeren van de operaties en voor het vergelijken van de normale met de hyperplastische condyli.

In hoofdstuk V is het begrip trauma uitgewerkt. Er zijn 6 experimentele groepen, waarbij telkens een ander soort gedefinieerd trauma aan het kaakgewricht is toegebracht. Er zijn bovendien 4 controle groepen ter vergelijking.

Uit de verschillende operatietechnieken is gebleken dat die waarbij het trauma heeft bestaan uit een extirpatie van de discus articularis, een statistisch significante hyperplasie van de condylus mandibulae heeft opgeleverd. De hyperplasie komt tot uiting als toeneming van de lengte van de sagittale en transversale as van het articulaire oppervlak van het betreffende caput mandibulae en ook als toeneming van de lengte van de opstijgende tak.

De transversale as van het articulaire oppervlak van de condylus is het meest in lengte toegenomen, vervolgens de sagittale as terwijl tenslotte de toeneming van de ramus ascenden slechts matig is. Deze toeneming is te danken aan de extirpatie van de discus articularis zelf.

Tevens zijn er aanwijzingen gevonden voor het ontstaan van een verlenging van de ramus ascenden na storingen van de veneuze bloedafvoer van de condylus. Het is niet uitgesloten dat de combinatie van partiële beschadiging van de arteriële bloedvoorziening en beschadiging van de veneuze bloedafvoer tot een hypoplasie van de condylus mandibulae zou kunnen leiden.

In dit experimenteel onderzoek is de extirpatie van de discus articularis gekozen, als de beste techniek in het kader van de doelstelling van het onderzoek.

In hoofdstuk VI vormen de volgende punten een onderwerp voor experimenteel onderzoek :

a. kan een partiële extirpatie van de discus articularis eveneens tot hyperplasie van het caput mandibulae leiden? De resultaten worden verge-

leken met de hyperplasie, verkregen na een totale extirpatie van de discus articularis.

b. wat is het gedrag van de discus articularis na excisie van een gedeelte ervan?
   In de discus zijn kleinere of grotere defecten aangebracht en is de genezingspotentie onderzocht.

c. treedt bij een dubbelzijdige extirpatie van de discus articularis een gelijkmatige en gelijkvormige hyperplasie beiderzijds op?

Vervolgens worden in dit hoofdstuk de histologische aspecten van de hyperplastische condylus besproken.

Uit de experimenten is gebleken dat een partiële extirpatie van de discus articularis evengoed tot hyperplasie van het caput mandibulae kan leiden als een totale extirpatie.

De discus articularis mandibulae is niet in staat de verschillende daarin aangebrachte defecten te herstellen.

Beschadigingen van het zogenaamde « retrodiscale pad » herstellen zich in betrekkelijk korte tijd.

Bij defecten van de discus articularis waarbij de rand hiervan betrokken is, treedt een verdere degeneratie van de discus op naar centraal toe.

Deze degeneratie is enigszins afhankelijk van de afmetingen van het aanvankelijk geëxcideerde gedeelte van de discus articularis.

In al deze gevallen is een gelijkmatige hyperplasie van de onderliggende condylus opgetreden.

In geval van kleine defecten van het centrale gedeelte van de discus blijft het defect onveranderd tot het einde van het experiment.

De onderliggende condylus is hier ook hyperplastisch. Het articulaire oppervlak tegenover het defect in de discus, heeft de neiging tot lokale proliferatie in de richting van het defect. Deze proliferatie komt het duidelijkste tot uiting in geval van zeer kleine defecten van het centrale gedeelte van de discus articularis.

Wat het onder c genoemde onderwerp betreft, blijkt het dat zelden beiderzijds een enigszins gelijkmatige en gelijkvormige hyperplasie optreedt na dubbelzijdige extirpatie van de discus articularis.

Dit kan te wijten zijn aan lokale factoren die het effect van de extirpatie van de discus articularis beïnvloeden. De toeneming in dikte van het kraakbeen aan de experimentele zijde is microscopisch gezien het meest opvallend. Alle kraakbeenlagen zijn in dikte toegenomen, behalve de articulaire zone welke in dit opzicht onveranderd is gebleven.

De cellen van de generatieve en intermediaire zone zijn ronder vergeleken met de normale zijde.
In de laag van de hypertrophische cellen zijn de cellen iets kleiner aan de experimentele zijde, vergeleken met die aan de controle zijde.
De endochondrale botvorming geschiedt in alle gevallen op normale wijze.
In hoofdstuk VII wordt onderzocht op welke wijze de hyperplasie zich ontwikkelt na een partiële of totale discus extirpatie.
Het is gebleken dat de ontwikkeling van de hyperplasie zich in eerste instantie uit als kraakbeenhyperplasie. De kraakbeenhyperplasie bereikt vrij abrupt een bepaalde dikte waarna deze verder constant blijft.
Dit geldt voor alle kraakbeenzonen behalve de articulaire zone. In latere stadia zijn er tekenen van regressie van het proces van kraakbeenhyperplasie waargenomen.
Het bot volgt deze ontwikkeling wat geleidelijker. Hier vindt in latere stadia eveneens een stabilisering van het hyperplasieproces plaats.
In hoofdstuk VIII wordt onderzocht in hoeverre het tijdstip van het uitvoeren van een extirpatie van de discus articularis van belang is voor het ontstaan van de hyperplasie van het caput mandibulae.
Het is gebleken dat wat het kraakbeen betreft het proces onafhankelijk is van de leeftijd van de experimentele dieren.
Wat het bot betreft schijnt het zo te zijn dat de hyperplasie, macroscopisch althans, wel van de leeftijd afhankelijk is. Bij de groep van zeer jonge dieren is macroscopisch na 16 dagen een verkorting van de processus articularis waargenomen, terwijl de condylus zelf hyperplastisch is.
Bij de groep van de jonge dieren is de condylus eveneens hyperplastisch. De lengte van de processus condylaris schijnt hier echter ten gunste van de experimentele zijde uit te vallen.

Bij oudere dieren is er macroscopisch geen verschil tussen de experimentele en de controle zijde, voor wat het ossale gedeelte betreft.

Histologisch gezien is er bij zeer jonge, bij jonge en bij volwassen dieren behalve de opvallende hyperplasie van het kraakbeen aan de experimentele zijde geen verder verschil tussen experimentele en controle zijde.

Bij seniele dieren is aan de experimentele zijde een « verjonging » van het kraakbeen waar te nemen.

De articulaire zone blijft ongewijzigd. De generatieve en intermediaire zone zijn duidelijk in dikte toegenomen.

Het meest opvallend echter is het opnieuw verschijnen van een zône van hypertrophische cellen aan de experimentele zijde.

Deze is meerdere cellagen dik. De omvang en het aspect van de cellen van deze laatste zone lijken op cellen uit dezelfde zone bij veel jongere dieren. Er wordt bovendien opnieuw endochondrale botgroei waargenomen.

Ἡ ἡμίπλευρος ὑπερπλασία τοῦ κονδύλου τῆς κάτω γνάθου
(πειραματική ἔρευνα)
Περίληψις

Εἰς τήν εἰσαγωγήν τῆς παρούσης διατριβῆς ἀναπτύσσονται αἱ σκέψεις αἵτινες ὁδήγησαν εἰς τήν περιγραφομένην πειραματικήν ἔρευναν. Ἐν ὀλίγοις αὗται ἔχουν ὡς ἑῆς :

Ἐκ τῆς μελέτης τῆς βιβλιογραφίας κατεφάνη ὅτι εἰς ὅ,τι ἀφορᾶ τήν αἰτιολογίαν τής παθήσεως, ὑποθέσεις μόνον ὑπάρχουν αἱ ὁποῖαι ἐπιπλέον διαφέρουν ἀπό συγγραφέως εἰς συγγραφέα. Ἡ παρούσα σκοπεῖ ἐις τήν ἔρευναν τῆς αἰτιολογίας τῆς ἡμιπεύρου ὑπερπλασίας τοῦ κονδύλου τῆς κάτω γνάθου.

Ἐγένετο προσπάθεια τεχνιτῆς ἀὐξήσεως τῶν διαστάεων τοῦ κονδύλου τῆς γνάθου ἐπί ζώων, δι 'ερεθισμοῦ τῆς διαδικσίας παραγωγῆς χονδρογενοῦς ὀστοῦ. Ὁ ἐρεθισμός ἐπιτυγχάνεται δἰ ἑνός καθωρισμένου τραύματος τῆς κροταφογνάθικῆς ἀρθρώσεως τῶν πειραμτοζώων.

Εἰς τό πρῶτον κεφάλαιον ἀναφέρονται τά δεδομένα βιβλιογραφίας οὕτως ὥστε ὁ ἀναγνώστης νά σχηματίση σαφή εἰκόνα τοῦ προβλήματος. Ἐν συντομίᾳ ταῦτα δύνανται νό συνοψισθοῦν ὡς ἑξῆς.

Ἡ ἡμίπλευρος ὑπερπλασία τῆς γνάθου δέν ἔχει κληρονομικόν χαρακτήρα. Οἱ πάσχοντες εἶναι κατά τά λοιπὰ ὑγιεῖς.

Δέν ὑπάρχουν εἰδικά κριτήρια διά τόν χαρακτηρισμόν τῆς παθήσεως. Οἱ συγγραφεῖς ὁμιλοῦν περί ἡμιπλεύρου ὑπερπλασίας τῆς γνάθου ἐφ'ὅσου ὁ εἷς κόνδυλος εἶναι "σαφῶς μεγαλύτερος" τοῦ ὡς "φυσιολογικοῦ" θεωρουμένου ἑτέρου κονδύλου. Ὁ τραυματισμός τῆς κροταφογναθικῆς ἀρθρώσεως ἀναφέρεται συχνά εἰς τήν βιβλιογραφίαν ὡς ἡ αἰτία τῆς νόσου.

Ἡ περαιτέρω ἔρευνα τῆς ἐννοίας "τραῦμα" ἐν ἐξαρτήσει πρός τήν ἡμίπλευρον ὑπερπλασίαν τοῦ κονδύλου τῆς γνάθου ἀποτελεῖ τό κύριον θέμα τῆς παρούσης διαρτιβῆς.

Εἰς τό δεύτερον κεφάλαιον ἀναφέρεται ἀριθμός χειρουργικῶν τεχνικῶν- ἀπόρροια τῆς μελέτης τῆς βιβλιογραφίας- σκοπούντων εἰς τόν ἐρεθισπόν τῆς διαδικασίας παραγωγῆς ἐνδοχονδρίου ὀστοῦ, γενικῶς, ἐφηρμοσμένων εἰς τήν γνάθον, εἰδικώτερον.

Εἰς τό τρίτον κεφάλαιον περιγράφονται αἱ γενικαί συνθῆκαι τοῦ πειράματος.

Εἰς τό τέταρτον κεφάλαιον ἀναπτύσσεται ἡ ἀνατομία, μικροσκοπική εἰκών καί ἡ αὔξησις τῆς φυσιολογικῆς κροταφογναθικῆς ἀρθρώσεως τοῦ πειραματοζώου.

Εἰς τό πέμπτον κεφάλαιον τελεῖται ἡ ἐπεξεργασία τῆς ἐννοίας "τραῦμα" Ἐκ τῆς ἀναλύσεως τῶν διαφόρων τύπων χειρουργκοῦ τραύματος καταφαίνεται ὅτι :

Ἐφ'ὅσον τό τραῦμα συνοψίζεται εἰς τήν ἀφαίρεσιν τοῦ ἐνδαρθρίου δίσκου τῆς κροταφογναθικῆς ἀρθρώσεως, ἔχει ὡς ἀποτέλεσμα τήν ὑπερπλασίαν τοῦ ὁμοπλεύρου κονδύλου. Ἡ ὑπερπλασία περιλαμβάνει τόσον τάς διαστάσεις τῆς ἀρθρικῆς ἐπιφανείας τοῦ κονδύλου ὅσον κατ τήν ἄὐξησιν τοῦ ἀνιόντος κλάδου τῆς γνάθου. Ἐπί πλέον εὐρέθησαν ἐνδείξεις ὅτι αὔξησις τοῦ ὕψους τοῦ κλάδου δύναται ἐπίσεις νά ἐπέλθη μετά διάτμησιν τῆς φλεβικῆς ὁδοῦ τοῦ κονδύλου.

Τέλος δέν δύναται νά ἀποκλεισθῆ ὅτι ἡ διάτμησις τῆς φλεβικῆς ὁδοῦ συνδυαζομένη μετά συγχρόνου,μερικῆς, διακοπῆς τῆς ἀρτηριακῆς ὁδοῦ, ὁδηγεῖ εἰς ὑποπλασίν τοῦ κονδύλου.

Εἰς τό ἔκτον κεφάλαιον ἐρευνῶνται τά ἀκόλουθα θέματα :

α) Ἔχει ἡ μερική ἀφαίρεσις τοῦ διαρθρίου δίσκου τῆς ΚΓΑ ὡς ἀποτέλεσμα τήν ὑπερπλασίαν τοῦ ὁμοπλεύρου κονδύλου τῆς γνάθου ;

β) Εἶναι ὁ διάρθριος δίσκος εἰς θέσιν νά ἀποκαταστήση ἀφαιρεθέν τμῆμα τῆς μάζης του ;

γ) Ὁδηγεῖ εἰς ὑπερπλαίαν τοῦ αὐτοῦ βαθμοῦ ἀμφιπεύρως, ἡ ἀμφίπλευρος ἀφαίρεσις τοῦ δίσκου ;

δ) Εἰς τό κεφάλαιον αὐτό περιγράφεται ἐπί πλέον ἡ ἱστολογική εἰκών τοῦ ὑπερπλασθέντος δίσκου.

Ἀποτελέσματα :

α) Ἡ μερική ἀφαίρεσις τοῦ δίσκου προκαλεῖ αὔξησιν τοῦ μεγέθους τοῦ ὁμοπλεύρου κονδύλου. Στατιστικῶς ἡ ὑπερπλασία αὕτη εἶναι τοῦ αὐτοῦ βαθμοῦ συγκρινομένη μέ τήν προκαλουμένην μετά ὁλικήν ἀφαίρεσιν τοῦ δίσκου.

β) Ὁ δίσκος τῆς ΚΓΑ δέν εἶναι εἰς θέσιν νά ἀποκαταστήση ἕν ἀφαιρεθέν τμῆμα αὐτοῦ. Ἀντιθέτως,ἐφ'ὅσον εἰς τό ἀφαιρεθέν τμῆμα περιλαμβάνεται τμῆμα τῆς περιφερείας, ἐπέρχεται περαιτέρω ἐκφύλισις μεγάλου τμήματος τοῦ δίσκου.
Ἐφ'ὅσον τό ἀφαιρεθέν μέρος περιλαμβάνει μόνον κεντρικόν τμῆμα τοῦ δίσκου δέν ἐπέρχεται περαιτέρω ἐκφύλισις. Αἱ διαστάσεις τοῦ ἀφαιρεθέντος τμήματος παραμένουν ἀμετάβλητοι.

γ) Ἡ ὑπερπλασία τῶν κονδύλων μετ'ἀμφίπλευρον ἐξαίρεσιν τοῦ δίσκου σπανίως εἶναι ἀμφοτεροπλεύρως τοῦ αὐτοῦ βαθμοῦ. Μικροσκοπικῶς εἶναι καταφανής ἡ ὑπερπλασία τοῦ χονδριχοῦ ἐπικαλύματος τοῦ κονδύλου. Ὅλαι αἱ ζῶναι ἐμφανίζουν ἐμφανή αὔξησιν τοῦ πάχους καί τοῦ ἀριθμοῦ τῶν κυττάρων ἐκτός τῆς ἀρθρικῆς ζώνης ἥτις παραμένει ἀμετάβλητος. Τά κύτταρα τῆς

βλαστικῆς ζώνης καί τῆς ζώνης ὡριμάνσεως εἶναι πλέον στρογγύλα ἐν συγκρίσει μετά ἀντίστοιχα τῆς ἀθίκτου πλευρᾶς. Τά κύτταρα τῆς ζώνης τῶν ὑπερτροφικῶν κυττάρων εἶναι μικρότερα. Αἱ ἐξεργασίαι τοῦ σχηματισμοῦ ἐνδοχονδρίου ὀστοῦ τελοῦνται φυσιολογικῶς. Ἡ τιτάνωσις,ὁ σχηματισμός πρωτογενοῦς καί μετέπειτα δευτερογενοῦς ὀστοῦ λαμβάνουν χώραν κατά φύσιν.

Εἰς τό ἕβδομον κεφάλαιον ἐρευνᾶται ὁ τρόπος κατά τόν ὁποῖον λαμβάνει χώραν ἡ ὑπερπλασία τοῦ κονδύλου.

Ἐν ἀρχῃ καθίσταται ὑπερπλαστικόν τό χόνδρινον ἐπικάλυμα τοῦ κονδύλου. Ὁ χόνδρος ἀποκτᾶ κάπως ἀπότομα ὡρισμένον πάχος τό ὁποῖον παραμένει περαιτέρω σταθερόν καθ' ὅλην τήν διάρκειαν τοῦ πειράματος. Τό ὀστέϊνον τμῆμα τοῦ κονδύλου ἀκολουθεῖ εἰς ἀργότερον ρυθμόν. Τελικῶς ἐπέρχεται καί ἐδῶ σταθεροποίησις τῆς καταστάσεως.

Εἰς τό ὄγδοον κεφάλαιον ἐρευνᾶται κατά πόσον ἡ ἡλικία τοῦ ζώου κατά τήν στιγμήν τῆς ἐπιφορᾶς τοῦ τραύματος παίζει ρόλον εἰς τήν ἀνάπτυξιν τῆς ὑπερπλασίας τοῦ κονδύλου τῆς γνάθου.

Διά μέν τό ὀστοῦν μακροσκοπικῶς τοὐλάχιστον,ἀποτελεῖ αὕτη σημαντικόν παράγοντα.

Τό χόνδρινον ἐπικάλυμα τοῦ κονδύλου καθίσταται ὑπερπλαστικόν ἀνεξαρτήτως ἡλικίας.

Ἱστολογικῶς εἶναι σημαντικαί αἱ παρατηρήσεις ἐπί τῶν παρασκευασμάτων ἐκ γεγηρασμένων ζώων. Ἡ ἱστολογική εἰκών τοῦ χόνδρου δέν εἶναι πλέον εἰκών χόνδρου γεγηρασμένου.

Ἡ ἀρθρική ζώνη παραμένει ἀμετάβλητος. Ἡ βλαστική ζώνη καί ἡ ζώνη ὡριμάνσεως συνίστανται ἐκ καταφανῶς ηὐξημένου ἀριθμοῦ κυττάρων. Σημαντική εἶναι καί ἡ ἐπανεμφάνησις τῆς ζώνης τῶν ὑπερτροφικῶν κυττάρων. Αὕτη ἀποτελεῖ ἐκ νέου παχείαν ζώνην ἐκ μορφολογικῶς τελειωμένων χονδροκυττάρων.

Παρατηρεῖται ἐπίσης ἡ παραγωγή νέου ἐνδοχονδρίου ὀστοῦ. Ἡ ὅλη εἰκών εἶναι ἐνδεικτική τῆς ἀναζωογονήσεως τοῦ κονδύλου.

REFERENCES

ADAMS (1936) : Cit. Rushton.

BAUER W., ROPES M.W., WAINE H. (1940) : The physiology of articular structures. Physiol. Rev. 20 272-312.

BAUME L.J., DERISCHWEILER H. (1961) : Is the condylar growth center responcive to orthodonthic therapy? Oral Surg. 14. 347-362.

BERNICK S. (1962) : The vascular and nerve supply to the temporomandibular joint of the rat. Oral Surg. 15.488-498.

BERRY D.C. (1958) : Mandibular condyle hyperplasia. Oral Surg. 11.420-425.

BISGARD J.D. (1936) : Longitudinal overgrowth of long bones with special reference to fractures. Surg. Gynec. Obstet. 62.823-834.

BLACKWOOD H.J.J. (1966) · Growth of the mandibular condyle of the rat studied with tritiated thymidine. Arch. Oral Biol. 11.493-500.

BLOMQUIST K., HOGEMAN K.E. (1963) : Benign unilateral hyperplasia of the mandibular condyle. Acta Chir. Scand. 126.414-426.

BOYD T.G., CASTELLI W.A., HULKF D.E. (1967) : Arterial supply of the Guinea pig mandible. J. Dent. Res. 46.1064-1067.

BOYER C.C., WILLIAMS T.W., STEVENS F H. (1964) : Blood supply of the temporomandibular joint. J. Dent. Res. 43.224-228.

BREITNER C. (1940) : Bone changes resulting from experimental orthodontic treatment. Am. J. Orthod. Oral Surg. 26.521-574.

BROADWAY R.T. (1958) : Two cases of unilateral hyperplasia of the mandibular condyle. Proc. R. Soc. Med. (Section of odonthology) 51.691-693.

BROOKES M. (1957) : Femoral growth after occulsion of the principal nutrient canal in days-old rabbits. J. Bone joint Surg. 39-B 563-571.

BROWN J.B., PETERSON L., CANNON B., MOORE A.M. (1946) : Facial asymmetry and malocclusion from hyperplasia of the mandibula. Plast. Reconstr. Surg. 1.284.287.

CERNÉA P. (1948) : Les déviations mandibulaires d'orgine épiphysaire. Rev. Stomatol. 49 388-413.

CERNÉA P., COMMISSIONAT Y., DALBIGNAT Y. (1956) : Les ostéomes du condyle du maxillaire inférieur. Rev. Belge Stomatol. 53.131-165.

CHARLIER J.-P., PETROVIC A., LINCK G. (1969) : La fronde mentonnière et son action sur la croissance mandibulaire. Recherches experimentales chez le rat. Orthod. Fr. 40.99-113.

CHARLIER J.-P., PETROVIC A., HERMANN STUFZMANN J. (1969) : Effects of mandibular hyperpropulsion on the prechondroblastic zone of young rat condyle. Am. J. Orthod. 55.71-74.

CHARLIER J.-P. (1967) : Les facteurs mécaniques dans la croissance de l'arc basal mandibulaire à la lumière de l'analyse des caractères structuraux et des propriétés biologiques du cartilage condylien. Orthod. Fr. 38.177-148.

CIMASONI G., BECKS H. (1963) : Growth study of the rat mandible as related to function. Angle Orthod. 33.27-33.

COLLINS D.A., BECKS H., SIMPSON M.E., EVANS H.M. (1946) : Growth and transformation of the mandibular joint in the rat. Normal femal rats. Am. J. Orthod. Oral Surg. 32.431-450.
COLT J.D., IGER M. (1963) : An attempt to stimulate bone growth by creating a venous stenosis. Angilogy 14.584-587.
COMMISSIONAT Y.A. (1952) : L'hypertrophie de l'apophyse condylienne du maxillaire inferieur Thèse Paris 1952.
CUNAT J.J., BHASKAR S.N., WEINMANN J.P. (1956) : Development of the squamoso-mandibular articulation in the rat. J. Dent. Res. 35.533-546.

DUBECQ X.-J. (1937) : Recherches morphologiques physiologiques et cliniques sur le ménisque mandibulaire; luxation habituelle et craquements temporo-maxillaires. J. Med. Bordeaux 114.125-178.
DUFOURMENTEL L. (1929) : Chirurgie de l'articulation temporo-maxillaire. Masson et Cie Paris.
DURKIN J.F., IRVING J.T., HEFLEY J.D. (1969) : A comparison of the circulatory and calcification patterns in the mandibular condyle in the Guinea pig with those found in the tibial epiphyseal and articular cartilages. Arch. Oral. Biol. 14.1365-1371.
DUTERLOO H S. (1967) : In vivo implantation of the mandibular condyle. Thesis Nijmegen. The Netherlands.

EGYEDI P. (1964) : Condylaire hyperplasie Ned. Tijdschr. Tandheelkd. 81.678-685.
EISELSBERG A. VON (1906) . Über schiefen Biss in Folge Arthritis eines Unterkieferkopfchens Arch. Klin. Chir. 79.587-592.
EVE (1883) : Cit. Mc. Nichol.
FERGUSON A.B. (1933) . Surgical stimulation of bone growth by a new procedure. J.A.M.A. 100.26.
FLOHR W. (1952) : Epihysare Hypertrophie des Unterkiefers durch enchondrale Knochenapposition am Processus articularis Dtsch. Zahnarzt. Z. 7.1235-1241.
FREITAG V. VON (1970) : Uber die sogenannte Hyperplasie des Kiefergelenkkopfes. Dtsch. Zahnarztl. Z. 25.655-662.
FURSTMAN L.L. (1966) : Normal age changes in the rat mandibular joint. J. Dent. Res. 45.291-296.

GOIDANICH I.F., CAMPANACCI M. (1962) : Vascular hamartomata and infantile angioectatic osteohyperphasia of the extremities. J. Bone Joint Surg. 44-A 815-841.
GOOF (1960) : Surgical treatment of unequal extremities. C.C. Thomas Springfield.
GOTTLIEB O. (1951) : Hyperplasia of the mandibular condyle. J. Oral Surg. 9.118-135.
GRAZIANI M. (1972) : Laterognathism, supraclusion and facial asymmetry from condylar hyperplasia. Oral Surg 33.884-887.
GREENE E.C. (1955) : Anatomy of the rat. New York Hafner.
GRUCA A., MEISSELS E. (1926) : Asymmetry of the mandible from unilateral hypertrophy. Ann. Surg. 83.755-767.
GULHUUS-MOE O. (1969) : Fractures of the mandibular condyle in the growth period. Thesis Oslo.

GUPTA O.P., FORREST E.J., SASOUNI V., MUNDELL R.D. (1971) : Studies on experimental malocclusion in rabbits. Method of induction of the malocclusion and its effects in the temporomandibular joint. Am. J. Orthod. 60.54-67.

HOCHMAN L.S., LASKIN D.M. (1965) : Repair of surgical defects in the articular surface of the rabbit mandibular condyle. Oral Surg. 19.534-543.

HOFFFR M O. (1958) : Les modifications de l'articulation temporo-mandibulaire par l'action des moyens orthopédiques. Orthod. Fr. 29. 97-146.

HUGHES P.C.R., TANNER J.M. 1(970) : A longitudinal study of the growth of the black-hooded rat : methods of measurement and rates of growth for skull, limbs, pelvis, nose-rump and tail lenghts. J. Anat. 106. 346-370.

HUGHES P C.R., TANNER J.M. (1970) : The assessment of skeletal maturity in growing rat. J. Anat. 106. 371-402.

HUI KE D.F., CASTELLI W.A (1965) : The blood supply of the rat mandible. Anat. Rec. 153. 335-342.

HUMPREY (1856) : Cit. Rushton.

HUTCHISON W.J., BURDEAUX B.D. (1954) : The influence of the stasis on bone growth. Surg. Gynecol. Obstet 99 413-420.

IVY R. (1927) : Benign bony enlargement of the condyloid process of the mandible. Ann. Surg. 85. 27-30.

KESSEL L. (1970) · Condylar hyperplasia; case report. Br. J. Oral Surg. 7. 124-126.

LAYANI F., FRANÇON J, COMMISSIONAT Y. (1954) : Hypertrophie de l'apophyse condylienne du maxillaire inférieur. Rev. Rhum. Mal. Osteoratic. 21. 159-161.

LEMOINE C., CHARLIER J.-P., PETROVIC A. (1968) : Réaction condylienne a la deviation mandibulaire provoquee chez le rat. Orthod. Fr. 39. 147-151.

LEPROUST (1927) : Les déviations du maxillaire d'origine épihysaire Leur traitement par la résection orthopédique du condyle. Thèse Paris.

LEVY B.M. (1948) . Growth of mandibular joint in normal mice J. Am Dent. Assoc. 36. 177-182.

LINDBLOOM G. (1960) : On the anatomy and function of the temporomandibular joint. Acta odont. Scand. Suppl. 28.

LINDEN F P.G M. VAN DER, BOERSMA H., ZELDERS T., PETERS K A , RAABEN J.H. (1972) : Three dimentional analysis of dental casts by means of the optocom. J. Dent. Res. 51. 1100-

MFI ARKEY D.W., ROFFINELLA J.P., KAPLAN H. (1966) : Osteocartilaginous exostosis (osteochondroma) of the mandibular condyle : report of case. J. Oral Surg. 24. 271-275.

MAC NICHOL W.J., ROGER A.T. (1946) : An orginal method of correction of hyperplastic asymmetry of the mandible. Plast. Reconstr. Surg. 1. 288-299.

Nomina Anatomica (1968) : Excepta Medica A'dam.

ÖBERG T., FAJFRS C.M., LYSELL O., FRIBERG U. (1962) : Unilateral hyperplasia of the mandibular condylar process. Acta Odont. Scand. 20. 485-504.

ÖBERG T. (1964) · Morphology, growth and matrix formation in the mandibular joint of the Guinea pig. Tans. R. Sch. Dent. Stockholm and Umea.

RÖNNING Ö., KOSKI K. (1969) : The effect of the articular disc on the growth of condylar cartilage transplants. Trans Europ Orthod Soc 99-108.

PERRIMAN A., UTHMAN A. (1971) Unilateral condylar hyperplasia. Br. J. Oral Surg. 8. 273-280.

PERTHÈS G. (1932) : Hypertrophie des Gelenkkopfchens Neue Deutsche Chirurgie 53. 159-162. Enke Verlag Stuttgart. (Verletzungen unde Krankheiten der Kiefer).

REICHENBACH E. VON, SEIDLER H. (1948) : Über die sogenannte « Hypertrophie des Kiefergelenkkopfchens » Dtsch Zahnarztl. Z. .3 806-811.

REITSMA J.W. (1963) : Het merken van laboratorium dieren Biotechniek 2. 135-143.

RUSHTON M A. (1946) : Unilateral hyperplasia of the mandibular condyle. Proc. R. Soc. Med. (Section of odontology). 39. 431-438.

SCHULTZ L.W., VAZIRANI S.J., BOLDEN T.E. (1960) : Unilateral hyperplasia and exostosis of the mandibular condyle. Oral Surg. 13. 387-395.

SCHILLINGS P.H M., HAAN J.C. DE (1964) . Beginselen der histopathologische techniek.

SCHUMACHER G.H. VON, REHMER H. (1962) : Über einige Unterschiede am Kauapparat bei Lagomorphen und Rodentia. Anat. Anz. 111. 103-122.

SERVELLE M. (1948) : Stase veneuse et croissance osseuse. Bull. Acad. Nat. Med. Paris 132. 471-474.

SPRINZ R. (1954) : Temporomandibular meniscectomy in rabbits. J. Anat. 88. 514-519.

SPRINZ R. (1961) : Further observations on the effect of surgery in the meniscus of the mandibular joint in rabbits. Arch. Oral Biol. 5. 195-201.

SPRINZ R. (1967) : Division of the neck of the mandible in rats. J. Anat. 101. 765-775.

THOMA K.H. (1945) : Hyperostosis of the mandibular condyle. Am. J. Orthod. Oral Surg. 31. 597-618.

VAUGHAN H.C. (1943) : A study of the temporomandibular articulation. J. Am. Dent. Assoc. 30-1501-1507.

WALKER R.V. (1967) : Condylar abnormalities. Oral surgery (Trans. 2nd Congress Int. Assoc. Oral Surgeons). 81-96.

WANG-NORDERUD R., LOSSIUS S. : Unilateral hyperplasia of the mandibular condyle. Acta Odont. Scand. 8. 44-52

WEINMANN J.P., SICHER H. (1955) : Bone and bones, 2nd ed. London Kimpton.

WORMAN H.G., WALDRON C W., RADUSCH D.F. (1946) . Osteoma of the mandibular condyle with deviation prognathic deformity. J. Oral Surg. 4. 27-32.

ZANCA P., MURPHY E. (1954) · Hypertrophy of the condyle of the mandible. U.S. Armed Forces. Med. J. 5. 1915-1819.

ZILE W.N. VAN, (1954) : Unilateral hyperplasia of the mandibular condyle. J. Oral Surg. 12. 275-283.

CURRICULUM VITAE

De auteur is geboren op 20 mei 1939 te Oud Korinthe, Griekenland. Hij volgde zijn middelbare schoolopleiding in Athene en begon in 1957 aan de Nationale en Capodistria Universiteit te Athene met de studie in de Tandheelkunde.
In 1963 werd het tandarts examen behaald.
Tot 1965 vervulde hij zijn militaire dienstplicht.
Vanaf februari 1966 tot februari 1967 was hij als assistent verbonden aan de afdeling Prothetische Tandheelkunde van de Katholieke universiteit te Nijmegen.
Vanaf februari 1966 tot februari 1970 heeft hij de opleiding tot specialist in de Mondheelkunde en Chirurgische Prothetiek gevolgd aan genoemde universiteit.
Sedertdien is hij als staflid verbonden aan de afdeling Mond- en Kaakchirurgie van de katholieke universiteit te Nijmegen.

STELLINGEN

1. Het is mogelijk een hervatting van de groei, zelfs van de seniele condylus mandibulae, te bewerkstelligen.

2. Bij jeugdige personen die een fractuur van de processus condylaris mandibulae hebben gehad, mag pas van een succesvolle genezing worden gesproken, indien zij gedurende enige jaren na het ongeval zijn gecontroleerd.

3. Extirpatie van de discus articularis mandibulae dient slechts bij uitzondering uitgevoerd te worden en alleen na een uitermate goed overwegen van voor- en nadelen.

4. Een onvolledige extirpatie van de discus articularis mandibulae is niet verantwoord.

5. Het suggereren van een secundaire reconstructie bij een vers trauma van het aangezicht, duidt op een onvoldoende inzicht in de mogelijkheden van de primaire behandeling en kan schade voor de patiënt tot gevolg hebben.

6. Het reponeren van de geluxeerde onderkaak vindt nog steeds plaats op de wijze die reeds door Hippokrates onderwezen is.

7. De beginselen van de behandeling van kaakfracturen zijn sinds Hippokrates onveranderd gebleven.

8. De literair meest verfijnde beschrijving van vrouwelijke schoonheid treft men aan in de Ilias van Homeros.

9. De hoofdpersoon in de operatiekamer is altijd de patiënt.

10. De relatieve vermindering van het grote aantal verenigingen is eerder te wijten aan de opkomst van de televisie dan aan een verandering in het nederlandse volkskarakter.

11. De hoeveelheid „antieke" voorwerpen die in Nederland met onverholen trots ten toon worden gesteld, doet vermoeden dat in de huizen der nederlandse voorvaderen voor henzelf geen plaats meer was.

GEDRUKT OP DE PERSEN VAN DE N.V. SCHEERDERS VAN KERCHOVE'S
VERENIGDE FABRIEKEN TE SINT-NIKLAAS.